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Video Camera

*Ins. Pt.* *IN 21*

BACKGROUND OF THE INVENTION

Field of the Invention

5           The present invention relates to a video camera for converting an object image imaged by a photographing optical system into an electrical signal using photoelectric conversion means.

*Description of the Related Art*  
Related Background Art

10           In recent years, a video camera for converting an object image imaged by a photographing optical system into an electrical signal using a photoelectric conversion element such as a solid-stage image pickup element, e.g., a CCD (charge coupled device), and  
15           recording the electrical signal onto a recording medium such as a magnetic tape has become popular. *To facilitate*  
*In view of*  
ease in use, video cameras are required to have compact structures, and compact video cameras have been developed by means of high-density electrical circuit  
20           packages, compact CCDs, compact photographing optical systems, and the like. At the present time, extensive studies continue to be made to realize *development of* further compact video cameras. For this reason, a further compact photographing optical system is *desirable* required.

25           The amount of light incident on an image pickup unit of a video camera is adjusted as follows. That is, an iris, which can mechanically adjust its aperture

Record attached

*a*  
*a*

1 size, is arranged in a photographing optical system,  
and the aperture size of the iris is adjusted.

2 However, since such a mechanical iris unit has a  
3 large driving motor unit, it is large in comparison to  
4 a photographing optical system lens barrel with a  
5 compact CCD. *This frustrates the*  
~~A problem associated with a compact iris~~  
~~unit disturbs~~ realization of a compact photographing  
optical system lens barrel.

6 It has been proposed that a material element such  
7 as a liquid crystal element, an EC (electrochromic)  
8 element, or the like <sup>be</sup> ~~is~~ used as an iris or a variable  
9 ND (neutral density) filter in place of the mechanical  
10 iris unit. However, these material elements still  
11 suffer from problems associated with wavelength  
12 dependency (spectral transmission factor) of a  
13 transmission factor, a small light transmission factor  
14 in a complete transmission state, a very narrow  
15 transmission factor adjustment range as compared to the  
16 above-mentioned mechanical iris, and the like. For  
17 these reasons, the material element has not yet been  
18 put into practical applications as an iris or a  
19 variable ND filter for ~~the~~ <sup>a</sup> photographing optical  
20 system.

#### SUMMARY OF THE INVENTION

21 The present invention has been made in  
22 consideration of the above situation, and has as its

1 object to provide a compact video camera by making a  
photographing optical system lens barrel compact.

It is another object of the present invention to  
solve various problems posed upon adjustment of the  
5 incident light amount using a material element.

In order to achieve the above objects, according  
to a preferred embodiment of the present invention,  
there is disclosed a video camera comprising: a  
material element, arranged in a photographing optical  
10 system, for controlling a light transmission factor or  
a light transmission amount; photoelectric conversion  
means for receiving an optical image transmitted  
through the material element at a position of an  
imaging plane, and converting the optical image into an  
15 electrical image signal; and correction means for  
correcting light transmission factor wavelength  
dependency of the material element in accordance with  
light transmission factor characteristics or light  
transmission amount characteristics of the material  
20 element.

According to the embodiment of the present  
invention, there is disclosed a video camera, wherein  
the correction means adjusts a correction amount of the  
light transmission factor wavelength dependency in  
25 accordance with the light transmission factor or the  
light transmission amount of the material element.

1           According to the embodiment of the present  
invention, there is disclosed a video camera, wherein  
the correction of <sup>by</sup> the correction means is achieved by  
auto white-balance control for an output signal from  
5   the photoelectric conversion means.

          According to the embodiment of the present  
invention, there is disclosed a video camera, wherein  
the correction of <sup>by</sup> the correction means is achieved by  
changing a sensitivity of the photoelectric conversion  
10   means in accordance with a light wavelength.

          According to the embodiment of the present  
invention, there is disclosed a video camera, wherein  
the correction of <sup>by</sup> the correction means is achieved by a  
filter provided to the photographing optical system or  
15   the photoelectric conversion means.

          According to the embodiment of the present  
invention, there is disclosed a video camera, wherein  
the correction of <sup>by</sup> the correction means is achieved by  
arranging another material element capable of  
20   controlling a light transmission factor in the  
photographing optical system.

          According to the embodiment of the present  
invention, there is disclosed a video camera, wherein  
the correction means comprises storage means for  
25   storing the light transmission factor wavelength  
dependency of the material element or the correction

1 amount of the light transmission factor wavelength  
dependency of the material element.

According to the embodiment of the present  
invention, there is disclosed a video camera, wherein  
5 the storage means stores a plurality of light  
transmission factor wavelength dependencies or a  
plurality of correction amounts in accordance with the  
light transmission factor or the light transmission  
amount of the material element.

10 In order to achieve the above objects, according  
to another preferred embodiment of the present  
invention, there is disclosed a video camera  
comprising: a material element, arranged in a  
photographing optical system, for controlling a light  
15 transmission factor or a light transmission amount;  
photoelectric conversion means for receiving an optical  
image transmitted through the material element at a  
position of an imaging plane, converting the optical  
image into an electrical image signal, and capable of  
20 adjusting at least one of a light accumulation time and  
a sensitivity; and exposure amount adjustment means for  
adjusting the light transmission factor or the light  
transmission amount of the material element, and at  
least one of the light accumulation time and the  
25 sensitivity of the photoelectric conversion means.

According to the embodiment of the present  
invention, there is disclosed a video camera, wherein

1 the exposure amount adjustment means electrically  
adjusts the light transmission factor or the light  
transmission amount of the material element.

According to the embodiment of the present  
5 invention, there is disclosed a video camera, wherein  
the exposure amount adjustment means adjusts the light  
transmission factor or the light transmission amount of  
the material element in accordance with incident light.

According to the embodiment of the present  
10 invention, there is disclosed a video camera, wherein  
the exposure amount adjustment means comprises storage  
means for storing at least one relationship between the  
light transmission factor or the light transmission  
amount of the material element and the light  
15 accumulation time or the sensitivity of the  
photoelectric conversion means.

It is still another object of the present  
invention to provide a compact video camera by making a  
photographing optical system lens barrel compact.

20 It is still another object of the present  
invention to provide a video camera, which can fully  
exhibit the performance of an iris adopting a material  
element which is arranged in a video camera.

Other objects and features of the present  
25 invention will become apparent from the following  
specification and the accompanying drawings.

1 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic sectional view showing an internal arrangement of a video camera according to the first embodiment of the present invention;

5 Fig. 2 is a block diagram showing a circuit arrangement according to the first embodiment of the present invention;

Fig. 3 is a graph showing an example of the light transmission factor wavelength dependency characteristics of a material element shown in Fig. 1;

Fig. 4 is a flow chart showing a control operation sequence according to the first embodiment of the present invention;

Fig. 5 is a block diagram showing a light transmission factor wavelength dependency correction circuit using a white-balance circuit according to the first embodiment of the present invention;

Fig. 6 is a block diagram showing a correction circuit for correcting the light transmittance factor wavelength dependency of a material element due to a change in temperature according to the second embodiment of the present invention;

Fig. 7 is an explanatory view showing a color filter arrangement of a color filter of an image pickup element shown in Fig. 1;

Fig. 8 is a graph showing the light transmission factor wavelength dependency characteristics of another

1 material element or a filter in the fourth embodiment  
of the present invention;

Fig. 9 is a schematic sectional view showing an  
internal arrangement of a video camera according to a  
5 modification of the fourth embodiment of the present  
invention;

Fig. 10 is a graph showing another example of the  
light transmission factor wavelength dependency  
characteristics of a material element which can be  
10 applied to the first embodiment of the present  
invention;

Fig. 11 is a schematic sectional view showing an  
internal arrangement of a video camera according to the  
fifth embodiment of the present invention;

15 Fig. 12 is a block diagram showing a circuit  
arrangement according to the fifth embodiment of the  
present invention;

Fig. 13 is a graph showing a program line for  
exposure amount control in the fifth embodiment of the  
20 present invention;

Fig. 14 is comprised of Figs. 14A and 14B are flow  
charts showing a control sequence of exposure amount  
control in the fifth embodiment of the present invention;

Fig. 15 is a block diagram showing a video camera  
25 according to the sixth embodiment of the present  
invention;



1        Fig. 16 is a block diagram showing a video camera  
according to the seventh embodiment of the present  
invention;

5        Fig. 17 is a block diagram showing a video camera  
according to the eighth embodiment of the present  
invention;

Fig. 18 is a block diagram showing a video camera  
according to the ninth embodiment of the present  
invention;

10       Fig. 19 is a block diagram showing a video camera  
according to the 10th embodiment of the present  
invention;

15       Fig. 20 is a block diagram showing a video camera  
according to the 11th embodiment of the present  
invention;

Fig. 21 is a block diagram showing a video camera  
according to the 12th embodiment of the present  
invention;

20       Fig. 22 is a block diagram showing a circuit  
arrangement in the 12th embodiment of the present  
invention;

Fig. 23 is a flow chart for controlling an  
operation of the 12th embodiment of the present  
invention;

25       Fig. 24 is a block diagram showing a video camera  
according to the 13th embodiment of the present  
invention;

1        Fig. 25 is a block diagram showing a circuit  
arrangement in the 13th embodiment of the present  
invention;

5        Fig. 26 is a block diagram showing the 14th  
embodiment of the present invention;

Fig. 27 is a block diagram showing the 15th  
embodiment of the present invention;

10       Fig. 28 is a graph showing an example of the  
spectral transmission characteristics of a near  
infrared light cut filter according to the 16th  
embodiment of the present invention;

15       Fig. 29 is a graph showing the spectral  
transmission characteristics of a material element  
according to the 16th embodiment of the present  
invention;

Fig. 30 is a graph showing the spectral  
transmission characteristics of the material element  
according to the 16th embodiment of the present  
invention;

20       Fig. 31 is a view showing an arrangement of the  
material element integrated with the near infrared  
light cut filter according to the 16th embodiment of  
the present invention;

25       Fig. 32 is a view showing another arrangement of  
the material element integrated with the near infrared  
light cut filter according to the 16th embodiment of  
the present invention;

1           Fig. 33 is a view showing still another  
arrangement of the material element integrated with the  
near infrared light cut filter according to the 16th  
embodiment of the present invention;

5           Fig. 34 is a view showing still another  
arrangement of the material element integrated with the  
near infrared light cut filter according to the 16th  
embodiment of the present invention;

10           Fig. 35 is a view showing still another  
arrangement of the material element integrated with the  
near infrared light cut filter according to the 16th  
embodiment of the present invention;

15           Fig. 36 is a block diagram showing a circuit  
arrangement according to the 17th embodiment of the  
present invention;

            Fig. 37 is a graph showing the light transmission  
factor wavelength dependency characteristics of a  
material element;

20           Fig. 38 is a graph showing the light transmission  
factor wavelength dependency characteristics of the  
material element in accordance with a change in  
temperature;

25           Fig. 39 is a schematic sectional view showing a  
video camera according to the 18th embodiment of the  
present invention;

1           Fig. 40 is a block diagram showing a circuit  
arrangement according to the 18th embodiment of the  
present invention;

5           Fig. 41 is comprised of Figs. 41A to 41C are flow  
charts for controlling the operation of a video camera  
according to the 18th embodiment of the present invention;

          Fig. 42 is a schematic sectional view showing a  
video camera according to the 19th embodiment of the  
present invention;

10          Figs. 43A and 43B are respectively a side view and  
a front view showing a material element according to  
the 20th embodiment of the present invention;

15          Figs. 44A to 44H are views showing a method of  
adjusting the transmission factor of the material  
element;

          Fig. 45 is a side view showing a light amount  
adjustment device according to the 21st embodiment of  
the present invention;

20          Figs. 46A and 46B are respectively a side view and  
a front view showing a light amount adjustment device  
according to the 22nd embodiment of the present  
invention;

25          Fig. 47 is a schematic sectional view showing main  
part of a video camera according to the 23rd embodiment  
of the present invention;

1        Fig. 48 is a schematic sectional view showing a  
video camera according to the 23rd embodiment of the  
present invention;

      Figs. 49A and 49B are flow charts showing an  
5       exposure amount control operation in the embodiment  
shown in Fig. 48;

      Figs. 50A and 50B are flow charts showing the  
second example of the exposure amount control  
operation;

10       Fig. 51 is a schematic sectional view showing a  
video camera according to the 24th embodiment of the  
present invention;

      Figs. 52A and 52B are flow charts showing an  
exposure amount control operation in the embodiment  
15       shown in Fig. 51;

      Fig. 53 is a flow chart showing the second example  
of exposure amount control processing corresponding to  
the embodiment shown in Fig. 51;

      Figs. 54A and 54B are flow charts showing the  
20       third example of exposure amount control processing  
corresponding to the embodiment shown in Fig. 51;

      Fig. 55 is a front view showing an arrangement of  
a material element used in the 23rd and 24th  
embodiments; and

25       Figs. 56A to 56H are explanatory views showing a  
method of adjusting the transmission factor of the  
material element shown in Fig. 55.

1 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments of the present invention will be described in detail hereinafter with reference to the accompanying drawings.

5 (First Embodiment)

Fig. 1 shows a schematic arrangement of an internal mechanism of a video camera according to the first embodiment of the present invention, Fig. 2 shows a circuit arrangement of this embodiment, and Fig. 3 shows the light transmission factor wavelength dependency characteristics of a material element used in this embodiment.

Referring to Fig. 1, a photographing optical system is constituted by a focus lens 1a for a focusing operation, a zoom lens 1b, and a stationary lens 1c. The focus lens 1a is held by a cylindrical focus lens holding frame 2, which has a gear portion 2a. A cylindrical stationary portion 3 is fixed to a camera body, and is threadably engaged with the focus lens holding frame 2. A cam cylinder 4 has a cam groove for determining the position of the zoom lens 1b, and is rotatably held by the stationary portion 3. The zoom lens 1b is held by lens frames 5 and 6.

The focus lens holding frame 2 is pivoted by a focus motor 7. A gear 7a is attached to the output shaft of the motor 7, and is meshed with the gear portion 2a of the focus lens holding frame 2. The cam

1 cylinder 4 is pivoted by a zoom motor 8. A gear 8a is  
attached to the output shaft of the motor 8, and is  
meshed with a gear portion 4a of the cam cylinder 4.

5 A material element 9 serving as an iris consists  
of, e.g., a liquid crystal capable of controlling the  
light transmission factor. An image pickup element 10  
comprises, e.g., a CCD. The photographing optical  
system has an optical axis 11.

10 An electronic viewfinder 12 has a lens 13. In  
addition to the above arrangement, the camera has a  
power switch 14 and a zoom operation unit 15. The  
camera also has a camera control circuit 21, and a  
recording unit 22 and a power source 23, which are  
electrically connected to the camera control circuit.  
15 The camera control circuit 21 is also electrically  
connected to the focus motor 7, the zoom motor 8, the  
material element 9, the image pickup element 10, the  
electronic viewfinder 12, the power switch 14, and the  
zoom operation unit 15.

20 As shown in Fig. 2, the camera control circuit 21  
is connected to a focus control circuit 24, a zoom  
control circuit 25, an exposure amount control circuit  
26, an image pickup element control circuit 27, an  
electronic viewfinder control circuit 28, and a  
25 recording unit control circuit 29, and is further  
connected to a photographing switch 30, a main switch

1 31, and a zoom switch 1 (32) and a zoom switch 2 (33)  
constituting the zoom operation unit 15.

5 The material element 9 shown in Fig. 1 comprises a  
liquid crystal element or an electrochromic element,  
serves as an iris for limiting the incident light  
amount, and can electrically control the light  
transmission factor or amount. *Ideally,* ~~it is ideal that~~ the  
material element 9 has a constant light transmission  
factor regardless of the wavelength of incident light.

10 In general, even when the light transmission factor of  
the material element is highest, the light transmission  
factor changes depending on the wavelength of incident  
light, as shown in Fig. 3. Referring to Fig. 3, R  
represents a red region, G represents a green region,  
15 and B represents a blue region.

For this reason, in this embodiment, in order to  
avoid a color balance error of an image caused by the  
material element 9, the white balance is corrected  
under the control of the camera control circuit 21, as  
20 will be described later.

Fig. 4 is a flow chart showing a control operation  
to be executed by the camera control circuit 21 of this  
embodiment. An operation of the first embodiment of  
the present invention will be described below with  
25 reference to this flow chart.

When a photographer operates the power switch 14  
of the camera to turn on the power source 23, the image



a pickup element 10 is driven (step S1) to move the focus lens 1a in the optical axis direction, so that the high-frequency components of a video signal output from the image pickup element 10 become <sup>a</sup>maximum. In order to move the focus lens 1a, the focus motor 7 is rotated. The gear 7a attached to the motor output shaft is meshed with the gear portion 2a of the focus lens holding frame 2, and the focus lens holding frame 2 is threadably engaged with the stationary portion 3. For this reason, the focus lens 1a is moved in the direction of the optical axis 11 upon rotation of the motor 7. A focusing operation is performed by this lens movement. At the same time, the light transmission factor of the material element 9 is controlled by the exposure amount control circuit, so that the amount of light incident on the image pickup element 10 becomes constant. In this control, as described above, in order to compensate for a color balance error caused by a change in light transmission factor depending on the wavelength of incident light, the white balance is corrected (step S2).

A video signal output from the image pickup element 10 and subjected to predetermined signal processing is displayed on the electronic viewfinder 12, and can be observed by the photographer (step S3) (this state will be referred to as a standby state hereinafter). In this state, when the photographer

1 operates the zoom operation unit 15 (steps S4, S5, and  
S7), the zoom motor 8 is rotated (steps S6 and S8).  
More specifically, since the gear 8a is meshed with the  
gear portion 4a of the cam cylinder 4, the cam cylinder  
5 4 is rotated upon rotation of the motor 8, and the zoom  
lens 1b is moved along the cam groove of the cam  
cylinder 4 in the direction of the optical axis 11,  
thus performing a zoom operation. The zoom operation  
unit 15 has the zoom switch (1) 32 and the zoom switch  
10 (2) 33. When the zoom switch (1) 32 is turned on  
(closed) (step S5), the zoom motor 8 is rotated forward  
(step S6), and the zoom lens 1a is moved toward the  
wide-angle end. On the other hand, when the zoom  
switch (2) 33 is turned on (step S7), the zoom motor 8  
15 is rotated backward (step S8), and the zoom lens 1b is  
moved toward the telephoto end. Note that the zoom  
switches 32 and 33 cannot be simultaneously turned on.

When the photographer depresses a photographing  
button (not shown) in step S4, the photographing switch  
20 30 is turned on. When the camera control circuit 21  
confirms that the photographing switch 30 is turned on  
(step S4), a photographing (image recording) operation  
is started (step S10). Thus, a video signal output  
from the image pickup element 10 is transferred to the  
25 recording unit 22 via the camera control circuit 21,  
and is converted into a signal format suitable for  
recording via the recording unit control circuit 29.

1       Thereafter, the converted signal is recorded on a  
recording medium such as an 8-mm video tape. At this  
time, the above-mentioned focusing operation and  
exposure amount adjustment are parallelly executed, and  
5       the video signal is displayed on the electronic  
viewfinder 12. The zoom operation is also performed  
according to an operation of the photographer in the  
same manner as described above (steps S11 to S15).  
When the photographer releases the photographing button  
10       (not shown), the photographing switch 30 is turned off  
(open). When the camera control circuit 21 confirms  
that the photographing switch 30 is turned off (step  
S16), the image recording operation is stopped (step  
S17), and the camera returns to the above-mentioned  
15       standby state (step S4).  
(Second Embodiment)

      A circuit arrangement for correcting the light  
transmission factor wavelength dependency of a material  
element using a white-balance adjustment circuit will  
20       be described below.

      As described above, when the material element is  
inserted in the photographing optical path, the color  
balance changes depending on the wavelength dependency  
of the light transmission factor, and is corrected by a  
25       white-balance adjustment circuit. In this case, if the  
wavelength dependency of the light transmission factor  
of the material element is always constant, the change

1 in color balance can be reliably corrected by the  
operation of the white-balance circuit.

However, when the wavelength dependency of the  
light transmission factor of the material element  
5 changes depending on the light transmission factor or  
temperature, flexible control is required.

Fig. 5 shows a white-balance adjustment circuit  
for a case wherein the wavelength dependency of the  
light transmission factor of the material element  
10 changes depending on the light transmission factor,  
i.e., a voltage applied to the material element (in,  
e.g., an EC element, the wavelength dependency changes  
according to its light transmission factor, i.e., an  
applied voltage), and Fig. 6 shows a white-balance  
15 adjustment circuit for a case wherein the wavelength  
dependency of the light transmission factor of the  
material element changes depending on a change in  
temperature. These white-balance adjustment circuits  
will be described below.

20 Fig. 5 is a block diagram showing an arrangement  
of the white-balance adjustment circuit for performing  
white-balance adjustment on the basis of an image  
pickup signal output from the image pickup element 10.  
This circuit is arranged in the camera control circuit  
25 21.

Referring to Fig. 5, a light beam transmitted  
through the material element as an iris for controlling

1 the incident light amount is incident on the image  
pickup element 10, and is photoelectrically converted  
into an image pickup signal to be output. Image pickup  
signals time-serially output from the image pickup  
5 element are sampled and held by sample-hold circuits  
34R, 34G, and 34B in accordance with the pixel  
arrangements of color filters of the image pickup  
element. R, G, and B components extracted by the  
sample-hold circuits 34R, 34G, and 34B are respectively  
10 smoothed by lowpass filters 35R, 35G, and 35B.

The R, G, and B signals respectively output from  
the lowpass filters 35R, 35G, and 35B are subjected to  
predetermined signal processing by a matrix circuit 38,  
and are respectively output as a luminance signal Y,  
15 and color difference signals R-Y and B-Y. These  
signals are supplied to a camera process circuit (not  
shown).

Multipliers 36R and 36B and gain control  
amplifiers 37R and 37B for varying gains are arranged  
20 at the output sides of the lowpass filters 35R and 35B.  
The R-Y signal and the B-Y signal output from the  
matrix circuit 38 are smoothed by lowpass filters 39R  
and 39B, and are supplied to differential amplifiers  
40R and 40B. The gain control amplifiers 37R and 37B  
25 are controlled by the outputs from the differential  
amplifiers 40R and 40B, thereby changing gains.

1           In this operation, the gain control amplifiers are  
controlled, so that the levels of the R-Y and B-Y  
signals become 0, thereby automatically executing  
white-balance adjustment.

5           The Y signal is supplied to a drive control  
circuit for controlling the transmission factor of the  
material element, and the transmission factor of the  
material element is controlled, so that an average  
value of the levels of the Y signal becomes a  
predetermined value. This operation itself corresponds  
10 to a so-called auto-iris operation.

          In the characteristic arrangement of this  
embodiment, a correction circuit 41 comprising a  
look-up table LUT, which stores the relationship  
between the transmission factors of the material  
15 element and the wavelengths, i.e., the transmission  
factors corresponding to colors, is arranged. Light  
transmission factor information 42a of the material  
element 9 is referred to, and correction coefficients  
according to a change in transmission factor in units  
20 of colors corresponding to the transmission factor are  
obtained with reference to the LUT. The correction  
coefficients are supplied to the multipliers 36R and  
36B, and are multiplied with the R and B signals,  
25 thereby canceling a change in wavelength dependency  
according to the light transmission factor of the  
material element.

a 1 More specifically, ~~when~~ <sup>when</sup> the light transmission factor is changed by changing a voltage to be applied to the material element so as to control the incident light amount, no problem is posed if transmission factors in units of wavelengths, i.e., colors, are balanced. However, in practice, the balance of transmission factors in units of colors changes depending on the light transmission factor, as shown in Fig. 10 (to be described later).

10 If such a change is merely corrected by a normal operation of the white-balance circuit, a change in color balance caused by a change in transmission factor of the material element cannot be discriminated from a change in color balance caused by a change in color temperature of an object field to be photographed while the transmission factor of the material element remains unchanged. Thus, when the color temperature of the object field changes, a wrong color correction is made. For example, even when the color of the object field changes, this change is corrected, and a color different from an actual color is undesirably recorded.

20 In order to solve this problem, in this embodiment, as for wavelength dependency caused by a change in light transmission factor of the material element, the transmission factor dependency characteristics of wavelengths according to the transmission factors of the material element are

1        prestored in the LUT in the form of correction  
coefficients, correction coefficients in units of  
wavelengths according to the transmission factor of the  
material element at that time are read out, and are  
5        supplied to the multipliers 36R and 36B. The R and B  
signals are respectively multiplied with the readout  
correction coefficients to achieve correction, so that  
the balance of changes in transmission factors at the  
respective wavelengths is left unchanged even when the  
10        transmission factor of the material element changes.  
More specifically, even when the transmission factor of  
the material element changes in Fig. 10, wavelength  
dependency characteristics ② can be maintained  
constant.

15        With this arrangement, an auto-iris apparatus  
using the material element can be realized without  
disturbing a normal white-balance operation.  
(Third Embodiment)

20        Fig. 6 shows a white-balance adjustment circuit  
considering a case wherein the wavelength dependency of  
the light transmission factor of the material element  
changes depending on a change in temperature. The  
arrangement shown in Fig. 6 is basically the same as  
that shown in the block diagram of Fig. 5, except that  
25        correction coefficients to be supplied to the  
multipliers 36R and 36B are those for correcting the  
light transmission factor dependency of wavelengths in



1 correspondence with a change in temperature, and are  
stored in a coefficient circuit 43 in the form of an  
LUT. The correction coefficients are referred to in  
accordance with an output from a temperature sensor TE,  
5 the correction coefficients corresponding to the  
detected temperature are read out from the coefficient  
circuit, and are supplied to the multipliers 36R and  
36B, thereby correcting a change in color balance  
caused by a change in temperature.

10 In this case as well, correction according to a  
change in temperature is performed outside a feedback  
loop for white-balance control, and temperature  
compensation can be performed without influencing a  
normal white-balance adjustment operation.

15 (Fourth Embodiment)

In the first and second embodiments described  
above, the light transmission factor wavelength  
dependency of the material element 9 is corrected by  
white-balance adjustment. This correction may be  
20 performed using a color filter of the image pickup  
element 10 in place of the white-balance adjustment.  
Fig. 7 shows an arrangement of the color filter of the  
image pickup element 10. This color filter is  
constituted by Mg (magenta), Cy (cyan), Ye (yellow),  
25 and G (green) filters. When the material element 9 has  
the light transmission factor wavelength dependency  
shown in Fig. 3, the light transmission factor of a

1 blue region (B) is smaller than those of a red region  
(R) and a green region (G), and the light transmission  
factors of the red region (R) and the green region (G)  
are almost equal to each other.

5 For this reason, when the light transmission  
factors of the cyan filter (Cy) and the magenta filter  
(Mg) shown in Fig. 7 are set to be larger than those of  
the yellow filter (Ye) and the green filter (G), the  
light transmission amounts of the respective wavelength  
10 regions can be corrected to be almost <sup>uniform</sup> ~~uniformed~~ at the  
position of the image pickup element 10.

At this time, when the areas of the cyan filter  
(Cy) and the magenta filter (Mg) are set to be larger  
than those of the yellow filter (Ye) and the green  
15 filter (G), the light transmission amounts of the  
respective wavelength regions can be corrected as well.

Alternatively, the light transmission factor  
wavelength dependency of the material element 9 may be  
corrected by changing the sensitivity levels of pixels  
20 of the image pickup element 10 corresponding to the  
respective filter portions. If the material element  
has characteristics different from those shown in  
Fig. 3, the light transmission factor wavelength  
dependency of the material element 9 can be corrected  
25 by adjusting the transmission factors or areas of the  
color filter, or the sensitivity levels of the image  
pickup element 10.

1           In addition, when the material element 9 has the  
characteristics shown in Fig. 3, light transmission  
factor wavelength dependency of the material element 9  
can be corrected by combining the element 9 with a  
5           correction filter 16 or another material element 17  
having opposite characteristics shown in Fig. 8. The  
correction filter 16 or the other material element 17  
may be arranged at a position different from the  
material element 9, as shown in Fig. 9, or may be  
10           arranged at the same position as the material element  
9, or may be arranged together with the image pickup  
element 10 or the color filter.

          When the transmission factor of the material  
element 9 is decreased, if the light transmission  
15           factor wavelength dependency characteristics change, as  
shown in, e.g., Fig. 10 (in the case of, e.g., an EC  
element), such a change may be corrected by the other  
material element 17 described above. Note that a curve  
① in Fig. 10 represents characteristics in a maximum  
20           transmission state, and a broken curve ② represents  
characteristics in a minimum transmission state.

          A storage circuit, which stores the light  
transmission factor wavelength dependency of the  
material element shown in Fig. 3 or its correction  
25           amounts, may be arranged, and the light transmission  
factor wavelength dependency of the material element  
may be corrected by the above-mentioned method (e.g.,

1 white-balance adjustment) using, e.g., the light  
transmission factor or amount of the material element  
or the amount of light incident on the photographing  
optical system.

5 When the light transmission factor wavelength  
dependency of the material element changes depending on  
the light transmission factor or amount of the material  
element, as shown in Fig. 10, a storage circuit, which  
stores a plurality of light transmission wavelength  
10 dependency characteristics in respective light  
transmission states (states with various light  
transmission factors or amounts) or corresponding  
correction amounts of the light transmission factor  
wavelength dependency characteristics, may be arranged.  
15 Thus, the light transmission factor wavelength  
dependency of the material element in each light  
transmission state may be corrected by the  
above-mentioned method (e.g., white-balance adjustment)  
using, e.g., the light transmission factor or amount of  
20 the material element or the amount of light incident on  
the photographing optical system.

As the material element 9 or 17, a material  
element whose light transmission factor decreases as  
the intensity of incident light increases may be used  
25 in place of an element for electrically controlling the  
light transmission factor.

1           The above embodiments and their modifications may  
be applied not only to a movie video camera but also to  
a still video camera.

(Fifth Embodiment)

5           The fifth embodiment of the present invention will  
be described below. Fig. 11 shows a schematic  
arrangement of an internal mechanism of a video camera  
according to the fifth embodiment of the present  
invention, and Fig. 12 shows a circuit arrangement of  
10 this embodiment. Referring to Fig. 11, the video  
camera has a material element 44, and the image pickup  
element 10 such as a CCD having a light accumulation  
time adjustment function (a so-called shutter  
function). The material element 44 is prepared by  
15 forming a transient metal oxide film ( $\text{IrO}_x$ ,  $\text{Ta}_2\text{O}_5$ ,  $\text{WO}_3$ ,  
or the like) on the surface of a glass plate, and can  
control the light transmission factor or amount of the  
film by applying a voltage to the film. This film is  
known to those who are skilled in the art. Referring  
20 to Fig. 12, a program storage circuit 45 stores a  
program used by the camera control circuit 21. Other  
arrangements are the same as those in the first  
embodiment of the present invention shown in Figs. 1  
and 2, and a detailed description thereof will be  
25 omitted.

Fig. 13 shows the content of a control program  
stored in the program storage circuit. In order to

1 achieve optimal exposure on the image pickup element  
10, the camera control circuit 21 performs control  
according to a program line shown in Fig. 13 stored in  
the program storage circuit 45. More specifically, the  
5 camera control circuit 21 causes the exposure amount  
control circuit 26 to control the light transmission  
factor or amount of the material element 44, so that  
the amount of light to be incident on the image pickup  
10 element 10 becomes constant. When incident light is  
too strong to control the incident light amount by the  
material element alone, the light transmission factor  
amount of the material element 44 is set to be a  
minimum value, and a high-speed shutter operation is  
15 realized using the shutter function of the image pickup  
element 10, thus achieving suitable exposure.

The exposure amount control sequence of the image  
pickup element 10 will be described below with reference  
to the flow charts shown in Figs. 14A and 14B. In a  
state wherein the incident light amount is adjusted by  
20 the above-mentioned material element 44 (steps S21 and  
S22), if the incident light amount increases (step  
S23), the camera control circuit 21 applies a voltage  
to the material element 44 to decrease the light  
transmission factor of the material element 44 (steps  
25 S24 and S25). However, when the incident light amount  
does not <sup>greatly</sup> ~~largely~~ change or when the incident light  
amount increases even if the voltage is applied to the

1 material element 44 for a predetermined period of time  
(steps S26 to S31), the camera control circuit 21  
determines that the incident light amount cannot be  
controlled by the material element 44 alone. The  
5 camera control circuit 21 increases the shutter speed  
using the shutter function of the image pickup element  
10 (steps S32 and S33), thus obtaining suitable  
exposure (step S34).

(Modification of Fifth Embodiment)

10 In addition, the same effect as that obtained by  
adjusting the exposure amount can be obtained by  
adjusting the sensitivity of the image pickup element  
10 in place of adjusting the light accumulation time of  
the image pickup element 10. If a material element  
15 whose light transmission factor decreases as the  
intensity of incident light increases is used in place  
of the material element 44 whose light transmission  
factor is controlled by a voltage, the exposure amount  
control can be achieved by controlling only the light  
20 accumulation time or the sensitivity of the image  
pickup element 10, thus simplifying control. With this  
arrangement, the exposure amount control circuit 26 and  
the program storage circuit 45 can be omitted, and  
exposure amount control can be achieved by the image  
25 pickup element control circuit 27 alone. As the  
material element 44, a material element whose light  
transmission factor changes according to both a voltage

1 and incident light intensity may be used or a liquid  
crystal element may be used. In addition, the fifth  
embodiment of the present invention can be applied not  
only to a movie camera but also to a still video  
5 camera.

As described above, according to the  
above-mentioned embodiments, since the light  
transmission factor wavelength dependency of the  
material element can be corrected, the material element  
10 can be used in place of an iris for mechanically  
adjusting an aperture portion of the photographing  
optical system. For this reason, since a drive unit  
for the iris for mechanically adjusting the aperture  
portion can be omitted, a compact photographing optical  
15 system lens barrel, i.e., a compact video camera can be  
provided.

Similarly, since the exposure amount of the video  
camera can be adjusted by the material element and the  
electronic shutter function of the image pickup element  
20 or sensitivity adjustment of the image pickup element  
in place of an iris for mechanically adjusting the  
aperture portion of the photographing optical system, a  
motor unit for the iris for mechanically adjusting the  
aperture portion can be omitted.

25 (Sixth Embodiment)

The sixth embodiment of the present invention will  
be described below.



1 In each of the above embodiments, a change in  
light transmission factor according to the wavelength  
occurring when a material element such as a liquid  
crystal or EC element is used as an iris is corrected  
5 by white-balance adjustment, a color filter, or the  
like. *The* ~~This~~ embodiment to be described below is  
achieved to improve an iris function obtained when a  
material iris is arranged in a video camera.

10 More specifically, a video camera for converting  
an object image imaged by a photographing optical  
system into an electrical signal using a photoelectric  
conversion element such as a CCD (charge coupled  
device), and recording the electrical signal onto a  
recording medium such as a magnetic tape has become  
15 popular. In view of ease in use, video cameras are  
required to have compact structures, and compact video  
cameras have been developed by means of high-density  
electrical circuit packages, compact CCDs, compact  
photographing optical systems, and the like. The iris  
20 of such a video camera photographing optical system  
adjusts the aperture portion area of the iris by an  
aperture blade prepared by adhering an ND filter to a  
portion of the aperture portion, and another aperture  
blade.

25 In order to meet the demand for a further compact  
video camera, the photographing optical system need be  
rendered further compact. However, since the

1 above-mentioned mechanical iris unit for adjusting the  
aperture area has a large motor unit, it is large in  
comparison to a photographing optical system lens  
barrel with a compact CCD. A problem associated with a  
5 compact iris unit disturbs realization of a compact  
photographing optical system lens barrel.

Therefore, attempts have been made to omit a drive  
unit for the conventional iris unit and to make the  
photographing optical system lens barrel compact by  
10 using a material element such as a liquid crystal  
element, an EC (electrochromic) element, or the like in  
place of the mechanical iris unit. Furthermore, it is  
required to make the material element compact, and to  
hold the material element in the photographing optical  
15 system lens barrel as easily as possible.

On the other hand, the video camera including the  
conventional mechanical iris unit suffers from the  
following problems.

More specifically, in an optical system having a  
20 small full-open aperture size, even if an ND filter is  
adhered to an aperture blade, the influence of  
diffraction appears near a small aperture state. Also,  
in the iris unit in which an ND filter is adhered to a  
blade portion, an out-of-focus image by the iris  
25 deteriorates.

This embodiment has been made to provide a video  
camera which can solve the above-mentioned problems.

1 In this video camera, since a material element capable  
of controlling the light transmission factor is  
provided to an optical element of a photographing  
optical system, no special frame for mounting the  
5 material element is required. Therefore, the size of  
the video camera can be prevented from being increased.  
Both the material element and the conventional  
mechanical iris unit are used commonly, thus  
eliminating the influence of diffraction.

*This*  
10 ~~The~~ embodiment of the present invention will be  
described below with reference to the accompanying  
drawings.

15 Fig. 15 is a schematic view showing an arrangement  
of a video camera according to the sixth embodiment of  
the present invention.

Referring to Fig. 15, a focus lens 1a, a zoom lens  
1b, and a stationary lens 1c constitute a photographing  
optical system. Note that the same reference numerals  
in Fig. 15 denote the same parts as in Fig. 1, and a  
20 detailed description thereof will be omitted. A  
material element 9 such as a liquid crystal element  
capable of adjusting the transmission light amount is  
arranged between a lens, closest to the image pickup  
plane side, of the photographing optical system, and  
25 the image pickup plane of the image pickup element 10.  
If at least one of optical systems arranged adjacent to  
the material element is a stationary optical system (in

1 this embodiment, an optical system at the object side  
of the material element is the stationary optical  
system), the material element 9 can be held by a  
holding lens barrel 46 for holding the stationary  
5 optical system, i.e., the stationary lens 1c. Thus,  
the material element can be easily held. The camera  
control circuit is electrically connected to the focus  
motor 7, the zoom motor 8, the material element 9, the  
image pickup element 10, the electronic viewfinder 12,  
10 the power switch 14, and the zoom operation unit 15,  
and controls these units. The focus lens 1a receives  
an effective light beam 16. Since the circuit  
connections of the video camera are the same as those  
in Fig. 2, and the operation control of the entire  
15 video camera is the same as that shown in the flow  
chart of Fig. 4, a detailed description thereof will be  
omitted.

In this embodiment, the material element 9 is held  
by the holding lens barrel 46 for the stationary lens  
20 1c. When the material element is arranged at a  
position adjacent to the stationary optical system, it  
can be easily held by the holding lens barrel for the  
stationary optical system without arranging any special  
holding member.

25 Also, when the material element is arranged at a  
position adjacent to an optical lowpass filter or an  
image pickup element, the material element can be

1 easily held by a holding member for the optical lowpass  
filter or the image pickup element.

However, when the material element is arranged  
adjacent to, e.g., the stationary optical system, if  
5 the material element undesirably becomes large in size,  
the material element may be arranged at a position  
where its two surfaces are adjacent to movable optical  
systems or may be held by a movable optical system  
holding lens barrel.

10 (Seventh Embodiment)

Fig. 16 is a schematic sectional view of a video  
camera according to the seventh embodiment of the  
present invention. The same reference numerals in  
Fig. 16 denote the same parts as in Fig. 15, and a  
15 detailed description thereof will be omitted. This  
embodiment is characterized in that an iris unit 45 for  
mechanically changing the aperture area using aperture  
blades is arranged in addition to the material element  
9 arranged in front of the image pickup element 10.  
20 Since this embodiment is arranged to decrease the light  
transmission factor of the material element 9 in the  
small aperture state of the iris unit 45, an image  
pickup operation of a high-luminance object can be  
realized without arranging any ND filter to the  
25 aperture blades of the iris unit 45. Thus, the  
influence of diffraction can be eliminated, and an

1 image including a good out-of-focus image by the iris  
can be obtained.

(Eighth Embodiment)

5 A video camera according to the eighth embodiment  
of the present invention will be described below with  
reference to Fig. 17. The same reference numerals in  
Fig. 17 denote the same parts as in Fig. 15, and a  
detailed description thereof will be omitted unless  
otherwise specified.

10 Referring to Fig. 17, a material element 9 such as  
an electrochromic (EC) element, which can adjust the  
transmission light amount by adjusting the density, is  
adhered to the stationary lens 1c.

15 The material element 9 used in this embodiment is  
also prepared by forming a transient metal oxide film  
( $\text{IrO}_x$ ,  $\text{Ta}_2\text{O}_5$ ,  $\text{WO}_3$ , or the like) on the surface of a glass  
plate, and can control the light transmission amount of  
the film by applying a voltage to the film.

20 An image pickup element 10 such as a CCD has an  
image pickup portion 10a, a color filter 10b, and a  
protection glass 10c. An optical lowpass filter 47 is  
arranged in front of the image pickup element 10.

25 Note that the arrangements and operations of  
various control circuits of the video camera of this  
embodiment are the same as those in the above  
embodiment, and an illustration of the circuit

1 arrangement and a description of the operations will be  
omitted.

The material element 9 may be formed on any of  
lenses of the photographing optical system. For  
5 example, when the photographing optical system includes  
a reflection mirror, the material element may be formed  
on the reflection surface of the reflection mirror.  
(Ninth to 11th Embodiments)

Fig. 18 shows the ninth embodiment wherein the  
10 material element 9 is formed on the rear surface of the  
optical lowpass filter 47.

Fig. 19 shows the 10th embodiment wherein the  
material element 9 is formed on the color filter 10b of  
the image pickup element 10.

15 Fig. 20 shows the 11th embodiment wherein the  
material element 9 is formed on the protection glass  
10c of the image pickup element 10.

According to these embodiments, since the material  
element capable of controlling the light transmission  
20 factor is arranged at or near a position corresponding  
to the minimum effective light beam diameter of the  
photographing optical system, the material element can  
be rendered compact, and its cost can be reduced.

Since the material element capable of controlling  
25 the light transmission factor is arranged on the lens  
surface of the photographing optical system, the  
optical low pass filter, an optical member of the image

1 pickup element, or the like, the material element can  
be rendered compact, its cost can be reduced, and the  
material element can be easily held. In addition,  
electrical wiring to the material element can be  
5 simplified.

When the material element is arranged at a  
position adjacent to the stationary optical system or  
the filter, the material element can be easily held by  
the holding member for the stationary optical system or  
10 the filter.

When both the iris for mechanically adjusting the  
aperture area using aperture blades and the material  
element are used, an optical system lens barrel which  
can eliminate deterioration of image quality caused by  
diffraction, and <sup>which</sup> can provide a good out-of-focus image  
15 by the iris, can be provided.

(12th Embodiment)

The 12th embodiment of the present invention will  
be described below.

20 In recent years, cameras, each of which extracts  
some light beams from a photographing optical system,  
guides the extracted light beams onto a photoelectric  
conversion element such as a CCD, and performs an  
auto-focus (AF) operation, an auto-exposure (AE)  
25 operation, and the like, have become popular.

In view of ease in use, such a camera is required  
to be rendered compact, and compact cameras have been



1 developed by means of high-density electrical circuit  
packages, compact photographing optical systems, and  
the like. As a means for making the photographing  
optical system compact, a camera, which adjusts the  
5 amount of light incident on the image pickup plane  
using a material element, has been proposed.

Similarly, in a video camera, which converts an  
object image picked up by a photographing optical  
system into an electrical signal using a photoelectric  
10 conversion element such as a CCD, and records the  
electrical signal on a recording medium such as a  
magnetic tape, it has been proposed to adjust the  
amount of light incident on the image pickup plane  
using a material element so as to realize a compact  
15 camera.

However, when the amount of light incident on the  
image pickup plane is to be adjusted by the material  
element constituted by a polarization plate and a  
liquid crystal, light passing through the material  
20 element is undesirably converted into linearly  
polarized light. When this light is incident on the  
reflection surface of a quick-return mirror, a  
pentagonal prism, or the like, the reflectance of the  
light varies depending on the direction of  
25 polarization. For this reason, the amount of light  
incident on the image pickup element for the AE or AF  
operation becomes different from the amount of light

1 incident on the image pickup plane, thus disturbing a  
precise AE or AF operation.

Assume that the amount of light incident on the  
image pickup plane of a video camera including an image  
5 pick element such as a CCD is to be adjusted using the  
material element. In this case, since the light  
transmitted through the material element is undesirably  
converted into linearly polarized light, even if this  
light is incident on an optical lowpass filter  
10 consisting of, e.g., crystal, an optical lowpass effect  
cannot be obtained.

Thus, this embodiment provides a camera and a  
video camera, which can solve the above-mentioned  
problems, and can make a photographing optical system  
15 lens barrel compact by adjusting the amount of light  
incident on the image pickup plane using a material  
element having a polarization plate.

As a practical means, there is provided a camera,  
which has a photographing optical system, a material  
20 element, having polarization means, for controlling a  
light transmission factor or amount in the  
photographing optical system, light reflection means,  
and photoelectric conversion means arranged on the  
image pickup plane of the photographing optical system  
25 or on a plane optically equivalent to the image pickup  
plane, comprising circularly polarizing light  
conversion means arranged on the image pickup plane

1 side of the material element or the side of the plane  
optically equivalent to the image pickup plane, wherein  
the light reflection means is arranged between the  
photoelectric conversion means and the circularly  
5 polarizing light conversion means. The material  
element and the circularly polarizing light conversion  
means are integrally arranged. There is also provided  
a camera, which has a photographing optical system, a  
material element, having polarization means, for  
10 controlling a light transmission factor or amount in  
the photographing optical system, light reflection  
means, and photoelectric conversion means arranged on  
the image pickup plane of the photographing optical  
system or on a plane optically equivalent to the image  
15 pickup plane, wherein the material element is arranged  
between the image pickup plane and the light reflection  
means.

According to this embodiment, there is provided a  
video camera, which has a photographing optical system  
20 including a material element, having polarization  
means, for controlling a light transmission factor or  
amount, and an optical lowpass filter, and has  
photoelectric conversion means arranged on the image  
pickup plane of the photographing optical system or on  
25 a plane optically equivalent to the image pickup plane,  
comprising circularly polarizing light conversion means  
arranged on the image pickup plane side of the material

1 element or the side of the plane optically equivalent  
to the image pickup plane, wherein the optical lowpass  
filter is arranged between the photoelectric conversion  
means and the circularly polarizing light conversion  
5 means. There is also provided a video camera, which  
has a photographing optical system including a material  
element, having polarization means, for controlling a  
light transmission factor or amount, and an optical  
lowpass filter, and has photoelectric conversion means  
10 arranged on the image pickup plane of the photographing  
optical system or on a plane optically equivalent to  
the image pickup plane, wherein the material element is  
arranged between the photoelectric conversion means and  
the optical lowpass filter.

15 With this arrangement, a photographing optical  
system lens barrel can be rendered compact, thus  
providing a compact camera and a compact video camera.

The 12th embodiment of the present invention will  
be described below with reference to the accompanying  
20 drawings. Fig. 21 is a schematic sectional view  
showing a camera according to the 12th embodiment of  
the present invention, Fig. 22 is a block diagram  
showing a circuit arrangement of this embodiment, and  
Fig. 23 is a flow chart showing an operation of this  
25 embodiment.

Referring to Figs. 21 to 23, a camera has a lens  
unit A and a camera body unit B. The lens unit A

1 includes a photographing optical system 101 constituted  
by a focus lens 101a, zoom lenses 101b and 101c, and a  
stationary lens 101d. A focus lens holding frame 102  
holds the focus lens 101a, and has a gear portion 102a.  
5 A stationary portion 103 is threadably engaged with the  
focus lens holding frame 102. The focus lens holding  
frame 102 is pivoted by a focus motor 104. A gear 104a  
is attached to the output shaft of the motor 104, and  
is engaged with the gear portion 102a of the focus lens  
10 holding frame 102. A material element 105 consisting  
of a polarization plate and a liquid crystal is  
arranged in front of the stationary lens 101d. A  
quarter-wave plate 107 is attached to the material  
element 105, and constitutes circularly polarizing  
15 light conversion means. The lens unit also includes a  
lens mount 108, and an optical axis 109 of the  
photographing optical system. The camera body unit B  
includes a quick-return mirror 111 having a half mirror  
portion, a sub mirror 112 attached to the quick-return  
20 mirror 111, a shutter unit 113, a pentagonal prism 114,  
a finder lens 115, an image pickup plane 116 such as a  
film surface, a camera contact 117, a camera mount 118  
which can be coupled to the lens mount 108, an AF  
sensor unit 119 having a photoelectric conversion  
25 element 119a such as a CCD, an AE sensor unit 120  
having a photoelectric conversion element, and a motor  
121 for driving the quick-return mirror 111. The lens

1 unit A also includes a lens control circuit 122  
electrically connected to the focus motor 104, the  
material element 105, and a lens contact 106. The  
camera unit B further includes a camera control circuit  
5 123, and a power source 124 electrically connected to  
the camera control circuit 123. The camera control  
circuit 123 is electrically connected to the shutter  
unit 113, the camera contact 117, the AF sensor unit  
119, the AE sensor unit 120, and the motor 121. The  
10 lens control circuit 122 and the camera control circuit  
123 are electrically connected to each other via the  
lens contact 106 and the camera contact 117.

The operation of the embodiment shown in Fig. 21  
will be described below with reference to Figs. 22 and  
15 23. When a power switch (not shown) of the camera is  
operated, and the power source 124 is turned on (S51),  
the light transmission factor of the material element  
105 is set to be maximum (S52). When a photographer  
determines a composition, and depresses a release  
20 button (not shown) to its half-stroke position, a  
switch 1 (Fig. 22) is turned on (S53). When the camera  
control circuit 123 detects that the switch 1 is turned  
on, the AE sensor unit 120 having the photoelectric  
conversion unit measures the luminance of an object.  
25 Also, the AF sensor unit 119 having the photoelectric  
conversion element measures the movement amount of the  
focus lens 101a for a focusing operation via a

1 photometry circuit 128 and a distance measuring circuit  
129 on the basis of light transmitted through the half  
mirror portion of the quick-return mirror 111, and  
reflected by the sub mirror 112. In addition, a power  
5 source voltage is checked (S54). Then, the shutter  
speed, the light transmission factor of the material  
element 105, and the movement amount of the focus lens  
101a are decided (S55). In this camera, the focus lens  
holding frame 102 is threadably engaged with the  
10 stationary portion 103, and the rotation of the focus  
motor 104 is transmitted to the focus lens holding  
frame 102 via the gear 104a and the gear portion 102a.  
For this reason, when the focus motor 104 is rotated by  
a focus motor control circuit 125, the focus lens 101a  
15 is moved in the optical axis direction while being  
rotated. The focus motor 104 is rotated based on the  
decided movement amount of the focus lens 101a to move  
the focus lens 101a to an in-focus position, thus  
achieving an AF operation (S56). When the release  
20 button is further depressed from this state, a switch 2  
(Fig. 22) is turned on (S57). When the camera control  
circuit 123 detects that the switch 2 is turned on, a  
material element control circuit 126 changes the light  
transmission factor of the material element 5 to the  
25 decided value (S59), and a quick-return mirror control  
circuit 131 causes the quick-return mirror 111 to  
be displaced  
escape from a light beam path (S60), as shown by the broken

1 line in Fig. 21. A shutter control circuit 130  
opens/closes the shutter unit 113 in accordance with  
the decided shutter speed value, thus performing  
exposure on the image pickup plane (film surface) 116  
5 (S61). The quick-return mirror 111 is returned to an  
original position (S62), and the light transmission  
factor of the material element 105 is set to be maximum  
again (original state) (S63). Then, a film is fed by  
one frame, thus ending a photographing operation (S64).

10 The function of the quarter-wave plate 107  
constituting the circularly polarizing light conversion  
means will be described below. When light incident  
from the object side (the left side in Fig. 21) into  
the photographing optical system is transmitted through  
15 the material element 105 having the polarization plate,  
it is converted into linearly polarized light. When  
the linearly polarized light is incident on the  
reflection surfaces of the quick-return mirror 111,  
since the reflectance varies depending on the direction  
20 of linear polarization, the sub mirror 112, and the  
pentagonal prism 114, the amount of light incident on  
the AE sensor unit 120 and the AF sensor unit 119  
varies depending on the direction of linear  
polarization even when the incident light amount  
25 remains the same, and precise photometry and distance  
measuring operations cannot be performed. In other  
words, precise AE and AF operations cannot be



1 performed. In order to perform precise photometry and  
distance measuring operations, the linearly polarized  
light must be converted into non-polarized light or  
circularly polarized light. Since the quarter wave  
5 plate 107 has a function of converting linearly  
polarized light into circularly polarized light, the  
quarter wave plate 107 can be arranged at an  
intermediate position between the material element 105  
and the reflection surfaces of the optical elements, so  
10 that light incident on each reflection surface can be  
converted into circularly polarized light.

*ds*  
~~Like~~ in this embodiment, when the quarter wave  
plate 107 and the material element 105 are integrally  
arranged, they can be arranged as a unit, and can be  
15 easily held. Note that the quarter wave plate 107 and  
the material element 105 need not always be integrally  
arranged.

(13th Embodiment)

The 13th embodiment of the present invention will  
20 be described below with reference to the accompanying  
drawings. Fig. 24 is a schematic sectional view  
showing an arrangement of a camera according to the  
13th embodiment of the present invention, and Fig. 25  
is a block diagram showing a circuit arrangement of the  
25 13th embodiment.

Note that the same reference numerals in Figs. 24  
and 25 denote the same parts or functions as in

1 Figs. 21 and 22, and a detailed description thereof  
will be omitted. Since the operation of the camera of  
the 13th embodiment is the same as that in the 12th  
embodiment of the present invention, a flow chart for  
5 controlling the operation of this embodiment will be  
omitted.

In the arrangement of the 13th embodiment, the  
material element 105 constituted by the polarization  
plate and liquid crystal is arranged between the  
10 quick-return mirror 111 and the image pickup plane  
(film surface) 116, and hence, the quarter wave plate  
is omitted. Except for this arrangement, the  
arrangement of the 13th embodiment is substantially the  
same as that of the 12th embodiment of the present  
15 invention. In this embodiment, <sup>before</sup> ~~when~~ the quick-return  
mirror 111 <sup>is displaced</sup> ~~escapes~~ from a light beam <sup>path</sup> (i.e., to a  
position indicated by a broken line in Fig. 24), i.e.,  
in an operation other than a photographing operation,  
light incident from the object side (the left side in  
20 Fig. 24) into the photographing optical system is  
transmitted through the reflection surfaces of the  
quick-return mirror 111, the sub mirror 112, and the  
pentagonal prism 114, is then incident on the AE sensor  
unit 120 and the AF sensor unit 119, and is used for  
25 photometry and distance measuring operations. When the  
quick-return mirror 111 <sup>is displaced</sup> ~~escapes~~ from a light beam in  
the photographing operation, light transmitted through

1 the photographing optical system is incident on the  
material element 105, and is subjected to light amount  
adjustment in a material element control circuit 133 to  
be converted into linearly polarized light. The  
5 linearly polarized light reaches the image pickup plane  
(film surface) 116. With this arrangement, precise  
photometry and distance measuring operations can be  
performed.

In addition, the camera of the 12th or 13th  
10 embodiment is an exchangeable lens type camera, but may  
be a lens integrated type camera.  
(14th Embodiment)

Fig. 26 is a schematic sectional view showing a  
video camera according to the 14th embodiment of the  
15 present invention.

The same reference numerals in Fig. 26 denote the  
same parts or functions as in Figs. 21 and 24, and a  
detailed description thereof will be omitted. A cam  
cylinder 134 for determining the positions of the zoom  
20 lenses 101b and 101c is rotatably held by a stationary  
portion 103. The zoom lenses 101b and 101c are held by  
lens frames 135 and 136. The focus lens holding frame  
102 is pivoted by a focus motor 137. A gear 137a is  
attached to the output shaft of the motor 137, and is  
25 engaged with the gear portion 102a of the focus lens  
holding frame 102. The cam cylinder 134 is pivoted by  
a zoom motor 138. A gear 138a is attached to the

1 output shaft of the motor 138, and is engaged with a  
gear portion 134a of the cam cylinder 134. A material  
element 139 is constituted by a polarization plate and  
a liquid crystal. An image pickup element 140  
5 comprises, e.g., a CCD. The photographing optical  
system has an optical axis 141. The camera of this  
embodiment also includes an electronic viewfinder 142  
having a lens 143, a power switch 144, a zoom operation  
unit 145, a quarter wave plate 146 adhered to the  
10 material element 139, and constituting circularly  
polarizing light conversion means, and an optical  
lowpass filter 147 utilizing birefringence. The camera  
further includes a camera control circuit, a recording  
unit, and a power source, which are electrically  
15 connected to the camera control circuit. The camera  
control circuit is also electrically connected to the  
focus motor 137, the zoom motor 138, the material  
element 139, the image pickup element 140, the  
electronic viewfinder 142, the power switch 144, and  
20 the zoom operation unit 145.

Note that the circuit arrangement and the control  
operation of the above-mentioned camera are the same as  
those in the circuit block diagram of Fig. 2, and the  
flow chart of Fig. 4 in the first embodiment, and a  
25 detailed description thereof will be omitted.

The function of the quarter-wave plate 146  
constituting the circularly polarizing light conversion

1 means will be described below. In a photographing  
operation, when light incident from the object side  
(the left side in Fig. 26) into the photographing  
optical system is transmitted through the material  
5 element 139 having the polarization plate, it is  
converted into linearly polarized light. Even when the  
linearly polarized light is incident on the optical  
lowpass filter 147 utilizing birefringence, an optical  
lowpass effect cannot be obtained. In order to obtain  
10 the function of the optical lowpass filter 147, the  
linearly polarized light must be converted into  
non-polarized light or circularly polarized light.  
Since the quarter wave plate 146 has a function of  
converting linearly polarized light into circularly  
15 polarized light, the quarter wave plate 146 can be  
arranged at an intermediate position between the  
material element 139 and the optical lowpass filter  
147, so that light incident on the optical lowpass  
filter 147 can be converted into circularly polarized  
20 light. *Like* in this embodiment, when the quarter wave  
plate 146 and the material element 139 are integrally  
arranged, they can be arranged as a unit, and can be  
easily held. Note that the quarter wave plate 146 and  
the material element 139 need not always be integrally  
25 arranged.

1 (15th Embodiment)

Fig. 27 is a schematic sectional view showing a video camera according to the 15th embodiment of the present invention. The same reference numerals in Fig. 27 denote the same parts as in the 14th embodiment shown in Fig. 26, and a detailed description thereof will be omitted. Also, since the circuit arrangement and operation of this embodiment are the same as those in the 14th embodiment (as in Figs. 2 and 4), blocks representing the circuit arrangement and the flow chart for controlling the operation will be omitted in this embodiment as well.

In the arrangement of this embodiment, the material element 139 constituted by a polarization plate and a liquid crystal is arranged between the optical lowpass filter 147 utilizing birefringence, and the image pickup element 140 such as a CCD, and no quarter wave plate is used. Except for this arrangement, the arrangement of this embodiment is substantially the same as that of the 14th embodiment of the present invention. In this embodiment, in a photographing operation, light incident from the object side (the left side in Fig. 27) into the photographing optical system is transmitted through the optical lowpass filter 147, and is subjected to an optical lowpass effect. Thereafter, the light is incident on the material element 139, and is subjected to light

1 amount adjustment. Thus, the light is converted into  
linearly polarized light, and reaches the image pickup  
element 140. With this arrangement, an optical lowpass  
effect can be obtained.

5 In addition, the video camera of the 14th or 15th  
embodiment of the present invention is a lens  
integrated type camera, but may be applied to an  
exchangeable lens type video camera.

As described above, according to the 12th  
10 embodiment, in a camera including a material element  
capable of controlling a light transmission factor or  
amount using polarization means in a photographing  
optical system, circularly polarizing light conversion  
means is arranged at the prospective imaging plane side  
15 of the material element, light reflection means is  
arranged between the circularly polarizing light  
conversion means and the prospective imaging plane, and  
the material element is arranged between the  
prospective imaging plate and the light reflection  
20 means. Therefore, a compact camera, which can perform  
precise AE and AF operations without arranging any  
exclusive circularly polarizing light conversion means  
can be provided.

Also, in a video camera including a material  
25 element capable of controlling a light transmission  
factor or amount using polarization means in a  
photographing optical system, circularly polarizing

1 light conversion means is arranged at the image pickup  
element side of the material element, an optical  
lowpass filter is arranged between the circularly  
polarizing light conversion means and the image pickup  
5 element, and the material element is arranged between  
the image pickup element and the optical lowpass  
filter. Therefore, a compact video camera, which can  
reliably obtain an optical lowpass effect, can be  
provided.

10 (16th Embodiment)

The 16th embodiment of the present invention will  
be described below..

When the amount of light incident on a  
photoelectric conversion element such as a CCD is  
15 adjusted by a material element such as an EC  
(electrochromic) element or a liquid crystal element,  
if control of the material element is stopped by  
turning off the power source of the camera or setting  
the camera in a reproduction mode when the light  
20 transmission factor of the material element is high,  
light having a strong light intensity, such as sunlight  
is incident on the photoelectric conversion element,  
and a damage may be caused in the photoelectric  
conversion element.

25 Since the photoelectric conversion element has  
high sensitivity to near infrared light outside a  
visible light range, a camera having the photoelectric



1 conversion element such as a CCD on the imaging plane  
of the photographing optical system or on a plane  
optically equivalent to the imaging plane has a near  
infrared light cut filter in the photographing optical  
5 system. Easy assembling of the near infrared light cut  
filter is a subject for realizing a compact, low-cost  
camera.

It is an object of this embodiment to provide a  
compact, low-cost camera having a photoelectric  
10 conversion element on an imaging plane of a  
photographing optical system or on a plane optically  
equivalent to the imaging plane, which camera adjusts  
the amount of light incident on the imaging plane by a  
material element, can prevent an image pickup element  
15 from being damaged with light having a high light  
intensity when the image pickup element is inactive,  
can improve easiness of assembling of the near infrared  
light cut filter, and can realize a compact, low-cost  
photographing optical system lens system.

20 For this reason, according to this embodiment,  
there is provided a camera, which has a material  
element capable of controlling a light transmission  
factor or amount in a photographing optical system, and  
has photoelectric conversion means on an imaging plane  
25 of the photographing optical system or on a plane  
optically equivalent to the imaging plane, wherein the  
material element has a filter function of removing near

1 infrared light. The material element and a filter for  
removing near infrared light are integrally arranged.  
The camera also has correction means for correcting the  
light transmission factor wavelength dependency  
5 characteristics of the material element. The camera  
further has storage means for storing the light  
transmission factor wavelength dependency  
characteristics of the material element obtained when  
the material element is in a predetermined state. The  
10 storage means stores a plurality of material element  
light transmission factor wavelength dependency  
characteristics when the light transmission factor of  
the material element is a predetermined value. The  
camera further has temperature detection means, and the  
15 storage means stores a plurality of material element  
light transmission factor wavelength dependency  
characteristics under a predetermined temperature  
condition. When the photoelectric conversion means  
does not perform a photoelectric conversion operation,  
20 the material element is set in a light shielding state  
or a substantially minimum light transmission factor  
state or a substantially minimum light transmission  
amount state, or when the photoelectric conversion  
means does not perform a photoelectric conversion  
25 operation, voltage application to the material element  
is stopped. At this time, when the voltage application  
to the material element is stopped, the light

1 transmission factor or amount is held in a state  
wherein voltage application to the material element is  
stopped. Furthermore, when the photoelectric  
conversion means stops a photoelectric conversion  
5 operation, the material element is set in a light  
shielding state or a substantially minimum light  
transmission factor state or substantially minimum  
light transmission amount state, and thereafter,  
voltage application to the material element is stopped.  
10 When the power switch of the video camera is turned  
off, the material element is set in a light shielding  
state or a substantially minimum light transmission  
factor state or substantially minimum light  
transmission amount state. The camera further includes  
15 reproduction means for reproducing a recorded image.  
When the video camera is set in a reproduction state of  
a recorded image or in a reproduction mode of a  
recorded image, the material element is set in a light  
shielding state or a substantially minimum light  
20 transmission factor state or substantially minimum  
light transmission amount state. The material element  
is one which can be set in a light shielding state or a  
substantially minimum light transmission factor state  
or substantially minimum light transmission amount  
25 state.

With the arrangement of this embodiment, a  
photographing optical system lens barrel can be

1 rendered compact, and its cost can be reduced, thus  
providing a compact, low-cost camera.

5 The 16th embodiment of the present invention will  
be described below with reference to the accompanying  
drawings. Since the arrangement and operation of the  
video camera of this embodiment are the same as those  
shown in Figs. 1 to 4 described in the first  
embodiment, a detailed description and illustration  
thereof will be omitted.

10 In this embodiment, a difference from the first  
embodiment is that a near infrared light cut filter  
function is added to the material element 9.

The material element 9 having the near infrared  
light cut filter function will be described below.

15 Fig. 28 shows an example of the spectral  
transmission characteristics of the near infrared light  
cut filter. Normally, an image pickup element such as  
a CCD has relatively high sensitivity to near infrared  
light. For this reason, in a camera having such an  
20 image pickup element, a near infrared light cut filter  
having spectral transmission factor characteristics  
shown in Fig. 28 is arranged at the light-receiving  
portion side of the image pickup element. For this  
reason, when a material element having spectral  
25 transmission characteristics shown in Fig. 29 (a solid  
curve in Fig. 29 represents a maximum transmission  
state of the material element, and characteristics

1 obtained when the light transmission factor is lowered  
are represented in the order of a broken curve, an  
alternate long and short dashed curve, and an alternate  
long and two short dashed curve) is used as light  
5 amount adjustment means for the photographing optical  
system, since this material element has a function of a  
near infrared light cut filter, the near infrared light  
cut filter need not be arranged in addition to the  
material element. A material element having spectral  
10 transmission characteristics shown in Fig. 30 (a solid  
curve in Fig. 30 represents a maximum transmission  
state of the material element, and characteristics  
obtained when the light transmission factor is lowered  
are represented in the order of a broken curve, an  
15 alternate long and short dashed curve, and an alternate  
long and two short dashed curve), and a near infrared  
light cut filter having characteristics shown in  
Fig. 28 are integrally arranged to constitute a light  
amount adjustment unit having spectral transmission  
20 characteristics shown in Fig. 29. Examples of the  
light amount adjustment unit will be explained below  
with reference to Figs. 31 to 35. In Figs. 31 to 35,  
common reference numerals are used. The light amount  
adjustment unit includes a near infrared light cut  
25 filter 216, a material element 217, and an EC  
(electrochromic) element 218 consisting of a transition  
metal oxide film (e.g.,  $\text{IrO}_x$ ,  $\text{Ta}_2\text{O}_5$ ,  $\text{WO}_3$ , or the like).

1 When a voltage is applied to this film, the  
transmission light amount of the film can be  
controlled. The adjustment unit also includes a liquid  
crystal 219, a polarization plate (or a glass plate)  
5 220, an electrical signal line 221, and a glass plate  
222. The above-mentioned light amount adjustment unit  
is prepared by integrally arranging the material  
element 217 and the near infrared light cut filter 216,  
as shown in Fig. 31. When the material element 217  
10 comprises an EC element, the EC element 218 may be  
formed on the surface of the near infrared light cut  
filter 216 by deposition, as shown in Fig. 32, or the  
glass plate 222 on which the EC element 218 is  
deposited may be adhered to the near infrared light cut  
15 filter 216, as shown in Fig. 33. One of the material  
element 217 and the polarization plate (or glass plate)  
220 sealed with a liquid crystal may be used as the  
near infrared light cut filter 216, or the liquid  
crystal element and the near infrared light cut filter  
20 216 may be adhered to each other, as shown in Fig. 35.  
The electrical signal line 221 shown in each of  
Figs. 31 to 35 is connected to the camera control  
circuit 21, and the material element 217 is controlled  
by the exposure amount control circuit 26.

25 (17th Embodiment)

The 17th embodiment of the present invention will  
be described below. The schematic arrangement of a

1 camera of this embodiment is basically the same as that  
shown in Fig. 21. The circuit arrangement of this  
embodiment is the same as that shown in the block  
diagram of Fig. 22, and operation control of the entire  
5 camera is the same as that shown in the flow chart of  
Fig. 23.

Therefore, the explanation for the arrangement and  
the operation shown in Figs. 21, 22, and 23 is used for  
those of this embodiment.

10 In this embodiment, however, the quarter wave  
plate 107 in Fig. 21 may be omitted.

An image pickup element such as a CCD used in,  
e.g., an AF sensor unit has relatively high sensitivity  
to near infrared light. For this reason, a near  
15 infrared light cut filter having spectral transmission  
factor characteristics shown in Fig. 28 is arranged at  
the light-receiving portion side of the image pickup  
element. For this reason, when the material element of  
the 16th embodiment of the present invention is used as  
20 a material element as light amount adjustment means in  
a photographing optical system of this embodiment,  
since the material element has a near infrared light  
cut filter function, another near infrared light cut  
filter need not be arranged. If light amount  
25 adjustment units having the arrangements (i.e.,  
integrated arrangements of the material element and the  
near infrared light cut filter) and spectral

1 transmission characteristics shown in Figs. 31 to 35  
like those in the 16th embodiment are used as the  
material element of this embodiment, the same effect  
can be obtained. In this case, in this embodiment, the  
5 electrical signal line 221 shown in each of Figs. 31 to  
35 is connected to the lens control circuit 122  
(Fig. 22), and the material element 105 is controlled  
by the material element control circuit 126.

In addition, the 16th embodiment of the present  
10 invention is applied to a photographing optical system  
integrated video camera, and the 17th embodiment of the  
present invention is applied to an exchangeable lens  
type camera. However, these embodiment may be applied  
to either a photographing optical system integrated  
15 camera or an exchangeable lens type camera.  
(18th Embodiment)

The 18th embodiment of the present invention will  
be described below. This embodiment compensates for a  
change in light transmission factor wavelength  
20 dependency of a material element caused by a change in  
temperature.

The schematic arrangement of a video camera  
according to the 18th embodiment of the present  
invention is the same as that shown in Fig. 21, and  
25 operation control of this camera is the same as that  
shown in the flow chart of Fig. 23. Fig. 36 is a block  
diagram showing a circuit arrangement of this



1 embodiment, Fig. 37 is a graph showing the light  
transmission factor wavelength dependency  
characteristics of a material element, and Fig. 38 is a  
graph showing a change in light transmission factor  
5 wavelength dependency characteristics of the material  
element caused by a change in temperature.

The arrangement shown in Fig. 36 is substantially  
the same as that in the first embodiment shown in  
Fig. 2, except that a material element spectral  
10 transmission factor characteristics storage circuit 322  
and a temperature detection circuit 321 are arranged.  
Thus, a detailed description thereof will be omitted.

The material element 9 and the spectral  
transmission factor characteristics storage circuit for  
15 the material element 9 will be described below with  
reference to Fig. 36.

The material element 9 comprises a liquid crystal  
element or an electrochromic element, and can  
electrically control the transmission amount of light.  
20 It is ideal that the material element 9 has a constant  
light transmission factor *independent* of the light  
wavelength. However, in general, even in a state  
wherein the material element has the maximum light  
transmission factor, the light transmission factor  
25 changes depending on the light wavelength, as shown in  
Fig. 37. In some material elements, the spectral  
transmission factor changes depending on the light

1 transmission factor, as indicated by, e.g., a broken  
curve in Fig. 37. In some cases, the spectral  
transmission factor may change depending on the  
temperature condition, as shown in Fig. 38. In order  
5 to prevent a color balance error of a camera due to use  
of this material element, this embodiment comprises the  
material element spectral transmission factor  
characteristics storage circuit 322 for storing the  
spectral transmission factor characteristics of the  
10 material element under respective conditions. The  
light transmission state of the material element, the  
temperature condition, and the like are detected by the  
camera control circuit or the temperature detection  
circuit 321, and white balance is corrected by the  
15 camera control circuit 123 on the basis of the spectral  
transmission factor characteristics of the material  
element 9 stored in the material element spectral  
transmission factor characteristics storage circuit  
322.

20 The operation of the 18th embodiment is the same  
as that shown in the flow chart of Fig. 4. That is,  
when the light transmission amount of the material  
element is controlled by the exposure amount control  
circuit, so that the amount of light incident on the  
25 image pickup element becomes constant, white balance is  
simultaneously corrected so as to prevent the

1 above-mentioned color balance error caused by material  
element 9 (see Fig. 6).

a In addition, when the spectral transmission factor  
characteristics of the material element do not ~~largely~~ *greatly*  
5 change due to a change in temperature, the temperature  
detection circuit 321 of this embodiment may be  
omitted, and white-balance correction due to the change  
in temperature may be omitted.

10 In this embodiment, the material element spectral  
transmission factor characteristics storage circuit 322  
is controlled by the camera control circuit 123. In  
the case of an exchangeable lens type camera, the  
material element spectral transmission factor  
characteristics storage circuit 322 may be arranged on  
15 the exchangeable lens side.

When color balance does not ~~largely~~ *greatly* change  
depending on the transmission factor of the material  
element, typical spectral transmission factor  
characteristics of the material element may be stored.

20 Color-balance correction is not limited to  
white-balance correction. For example, the color  
balance may be corrected by any other methods (e.g., by  
changing the transmission factor of the color filter of  
the image pickup element).

a  
25 (19th Embodiment)

Fig. 39 is a schematic sectional view showing a  
video camera according to the 19th embodiment of the

1 present invention, Fig. 40 is a block diagram showing a  
circuit arrangement of this embodiment, and Figs. 41A  
to 41C are flow charts for controlling the operation  
of the video camera of this embodiment.

5 The same reference numerals in Fig. 39 denote the  
same parts or functions as in Fig. 1 of the first  
embodiment, and a detailed description thereof will be  
omitted.

10 Referring to Fig. 39, a mode change switch 400 is  
used for switching an operation mode between a  
recording mode and a reproduction mode. The camera has  
the camera control circuit 21, and the recording unit  
22 and the power source 23, which are electrically  
connected to the camera control circuit 21. The camera  
15 control circuit 21 is also electrically connected to  
the focus motor 7, the zoom motor 8, the material  
element 9, the image pickup element 10, the electronic  
viewfinder 12, the power switch 14, the zoom operation  
unit 15, and the mode change switch 400.

20 The operation of this embodiment will be described  
below with reference to Figs. 40 and 41A to 41C. In the  
following description, a brief explanation will be  
given for the same points as in the first embodiment  
shown in Figs. 1 and 2.

25 The power switch 14 of the camera is operated to  
turn on the power source (S101), and it is checked if  
the camera is set in a recording mode by the mode

1 change switch 400 (S102). If YES in step S102, the  
image pickup element is driven to move the focus lens  
1a in the optical axis direction, so that the  
high-frequency components of a video signal output from  
the image pickup element 10 become <sup>maximized</sup> ~~maximum~~. The light  
transmission amount of the material element is  
controlled to obtain a constant image pickup signal  
level, thus performing exposure amount control (S104).  
At this time, the electronic viewfinder is turned on,  
10 and a photographed image can be observed (standby  
state).

It is checked if the power switch is ON (S106), it  
is checked if the recording mode is selected (S107),  
and it is then checked if the photographing switch is  
15 ON (S108). If it is determined in step S108 that the  
photographing switch is ON, image recording is started  
(step S109), and the forward/backward rotation of the  
zoom motor is controlled in accordance with the ON/OFF  
states of the zoom switches 1 and 2, thus allowing a  
20 zoom operation during a photographing operation (S110  
to S114). It is checked again if the photographing  
switch is ON (S115). If YES in step S115, the flow  
returns to step S110; otherwise, image recording is  
stopped (S116), the zoom motor is stopped (S117), and  
25 the control returns to the standby state in step S106.

Even if it is determined in step S108 that the  
photographing switch is OFF, processing in steps S118

1 to S120 allows a zoom operation. A zoom operation in  
this case is the same as that in steps S110 to S114.

5 If it is determined in step S107 that the mode  
change switch is turned off to select a reproduction  
mode, the focus lens is stopped to stop a focusing  
operation (S123), and the drive operation of the  
material element is stopped to stop an exposure control  
operation (S124). Also, the drive operation of the  
10 image pickup element is stopped (S125). Furthermore,  
the light transmission factor of the material element  
is held to be a minimum value (S126). Thus, scorching  
of, e.g., the image pickup element due to incidence of  
strong light can be prevented. In this manner, the  
operation mode can be switched from the recording  
15 standby state to the reproduction mode.

If it is determined in step S106 that the power  
switch is turned off, the focusing operation is stopped  
(S127), the exposure amount control operation is  
stopped (S128), and the drive operation of the image  
20 pickup element is stopped (S129). Thereafter, the  
light transmission factor of the material element is  
held to be a minimum value (S130), and the electronic  
viewfinder is turned off (S131). Thus, the control  
ends (S132).

25 When the power switch 14 of the camera is operated  
to turn on the power source, and the camera is set in  
the reproduction mode by the mode change switch 400

1 (S102), the light transmission factor of the material  
element 9 is held to be a minimum value by the exposure  
amount control circuit 105. At this time, when a  
reproduction button (not shown) is depressed (S133), an  
5 image stored in a recording medium inserted in the  
camera is displayed on the electronic viewfinder 12  
(S134). When a stop button (not shown) is depressed  
(S135), the image reproduction is stopped (S136). In  
this state, when the power switch 14 is turned off, the  
10 camera control circuit 21 confirms that the power  
switch 14 is turned off, and the image display on the  
electronic viewfinder is stopped. At the same time,  
the material element 9 is held in a minimum light  
transmission factor state. In this manner, the power  
15 source of the camera is turned off (S137 → S130).

When the camera control circuit 21 confirms that  
the operation mode of the camera is switched from the  
reproduction mode to the recording mode by the mode  
change switch 400 (S138), the drive operation of the  
20 image pickup element 10, the focusing operation, the  
zoom operation, the exposure amount control operation,  
and the like are started, as described above, and the  
camera is set in the standby state of the recording  
mode (S138 → S103).

25 A method of setting the light transmission factor  
or amount of the material element in a minimum state,

1 and holding this state in this embodiment will be  
described below.

When the light transmission factor or amount of  
the material element of this embodiment becomes minimum  
5 if no voltage is applied to the material element (e.g.,  
a negative type liquid crystal element), energization  
to the material element need only be turned off so as  
to set the light transmission factor or amount of the  
material element in a minimum state and to hold this  
10 state.

When the light transmission factor or amount of  
the material element of this embodiment is held in a  
state obtained when energization to the material  
element is turned off (e.g., an EC element),  
15 energization need only be performed until the light  
transmission factor or amount of the material element  
has a minimum state, and thereafter, the energization  
can be turned off, so as to set the light transmission  
factor or amount of the material element in a minimum  
20 state and to hold this state (for example, a constant  
voltage is applied for a predetermined period of time).

When the image pickup element is not active (e.g.,  
when the power source of the camera is OFF, when the  
camera is set in the reproduction mode, and the like),  
25 the material element 9 is held in the minimum light  
transmission state, but may be held in a state near the



1 minimum light transmission state or in a light  
shielding state.

As described above, according to the 16th to 19th  
embodiments of the present invention, in the camera  
5 which has the photographing optical system including  
the material element capable of controlling the light  
transmission factor or amount, and the photoelectric  
conversion means on the imaging plane of the  
photographing optical system or on a plane optically  
10 equivalent to the imaging plane, since the material  
element has a near infrared light cut filter function  
or is arranged integrally with a near infrared light  
cut filter, <sup>ease</sup>~~easiness~~ of assembling of the near infrared  
light cut filter can be improved, and the size and cost  
15 of the photographing optical system lens barrel can be  
reduced, thus providing a compact, low-cost camera.

Since the material element light transmission  
factor wavelength dependency characteristics storage  
circuit and the color balance correction means are  
20 arranged, the material element can be used in place of  
a conventional iris for mechanically adjusting an  
aperture portion, and a drive unit for the iris for  
mechanically adjusting the aperture portion can be  
omitted, thus providing a compact photographing optical  
25 system lens barrel, i.e., a compact video camera.

1           Also, the material element can be used in an  
exchangeable lens type video camera in place of the  
conventional iris.

5           In the video camera, which has the photographing  
optical system including the material element capable  
of controlling the light transmission factor or amount,  
when the image pickup element is not active, or when  
the power source of the camera is turned off, the  
material element is set in a light shielding state, or  
10          a minimum light transmission factor state or a state  
near the minimum light transmission factor state, or a  
minimum light transmission amount state or a state near  
the minimum light transmission amount state. For this  
reason, a compact video camera which can eliminate ~~a~~  
15          damage to the image pickup element <sup>due to</sup> ~~upon~~ incidence of  
light having a strong light intensity can be provided.

          The 19th embodiment of the present invention will  
be described below.

20          This embodiment relates to an optical system  
having a light amount adjustment device and, more  
particularly, to an optical system having a light  
amount adjustment system, which is suitable for a  
camera such as a video camera, an electronic still  
camera, a still camera, and the like, which camera can  
25          widen the passing light amount adjustment range of the  
optical system by arranging a plurality of material  
elements capable of arbitrarily adjusting the

1 transmission factor (light transmission factor) in the  
optical path of the optical system.

As described above, in order to realize a compact  
photographing optical system, attempts have been made  
5 to control the light amount adjustment range of the  
optical system by arranging a material element such as  
a liquid crystal element, an electrochromic (EC)  
element, or the like in the optical path of the optical  
system as a light amount adjustment device for  
10 adjusting the amount of light incident on an imaging  
plane in a video camera.

Even in a camera using a silver chloride film, a  
proposal has been made to control the amount of light  
beam incident on an imaging plane by utilizing a  
15 material element such as a liquid crystal element so as  
to realize an electronic iris device.

The conventional iris device for performing light  
amount adjustment by mechanically moving aperture  
blades to change the aperture size allows about 10 to  
20 12 iris steps (the light amount ratio (maximum  
transmission light amount/minimum transmission light  
amount) of about 1,000 to 4,000) of light amount  
adjustment in a video camera. Also, in a video camera  
using a silver chloride film, the iris device allows  
25 about 5 to 8 iris steps (the light amount ratio of  
about 30 to 250) of light amount adjustment.

1           The light amount adjustment devices used in these  
cameras can adjust the passing light amount  
(transmission light amount) within a relatively wide  
range. However, the entire device becomes large in  
5 size, and is complicated.

          In contrast to this, in another light amount  
adjustment device, a material element such as a liquid  
crystal element, an EC element, or the like is solely  
arranged in an optical path of an optical system, and  
10 the amount of light incident on an imaging plane is  
adjusted by changing the transmission factor of the  
material element. Such a light amount adjustment  
device is suitable for achieving the photographing  
optical system. However, it is difficult for this  
15 light amount adjustment device to perform light amount  
adjustment within a range as wide as that of the  
above-mentioned mechanical light amount adjustment  
device (iris device).

          For this reason, the light amount adjustment range  
20 becomes insufficient, and a desired image cannot be  
easily obtained.

          When the passing light amount of the optical  
system is to be adjusted by changing the transmission  
factor (density) of a single material element, a  
25 sufficient iris effect cannot be obtained. As a  
result, the depth of field cannot be increased, and  
harmful light beams cannot be effectively shielded.

1           The present invention has as its object to provide  
an optical system having a compact light amount  
adjustment device, which can obtain a wider light  
amount adjustment range, and can obtain a sufficient  
5   iris effect by arranging a plurality of material  
elements capable of arbitrarily adjusting the  
transmission factor in the optical path of the optical  
system.

10           An optical system having a light amount adjustment  
device of this embodiment is characterized in that the  
passing light amount is controlled by arranging a  
plurality of material elements capable of adjusting the  
transmission factor in the optical path of the optical  
system.

15           Also, an optical system having a light amount  
adjustment device of this embodiment is characterized  
in that when the passing light amount is controlled by  
arranging a plurality of material elements capable of  
adjusting the transmission factor in the optical path  
20   of the optical system, a light transmission region of  
at least one of the plurality of material elements is  
divided into a plurality of regions, and the  
transmission factor of at least one of the plurality of  
divided regions can be adjusted independently of the  
25   other regions.

Fig. 42 is a block diagram showing an arrangement  
of a video camera of this embodiment. The circuit

1 arrangement and operation control of this embodiment  
are the same as those shown in the block diagram of  
Fig. 2 and the flow chart of Fig. 4 according to the  
first embodiment, and a detailed description thereof  
5 will be omitted.

The same reference numerals in Fig. 42 denote the  
same parts as in Fig. 1, and a detailed description  
thereof will be omitted.

Referring to Fig. 42, material elements 9 and 401  
10 comprise liquid crystal elements, electrochromic (EC)  
elements (e.g., prepared by forming a conductive film  
of, e.g., a transition metal oxide ( $\text{IrO}_x$ ,  $\text{Ta}_2\text{O}_5$ ,  $\text{WO}_3$ , or  
the like) on the surface of a glass plate having a  
thickness of about 0.3 to 1 mm), and the like. The  
15 material elements 9 and 401 have a function of  
arbitrarily controlling their transmission factors or  
amounts upon application of a voltage thereto.

In this embodiment, the material element 9 is  
arranged near an iris in an optical path between a zoom  
20 lens 1b2 and the stationary lens 1c, and the material  
element 401 is arranged in an optical path in front of  
the focus lens 1a. The two material elements 9 and 401  
arbitrarily adjust the passing light amount  
(transmission light amount) of a light beam of the  
25 optical system (photographing optical system 1 to widen  
the light amount adjustment range, thus performing  
proper exposure.

1           Other arrangements are the same as those in the  
block diagram shown in Fig. 1, and the respective  
components are controlled by the camera control  
circuit.

5           Although the operation control sequence is the  
same as that in the first embodiment shown in Fig. 4,  
the light transmission amount and the light  
transmission factor are controlled by a combination of  
both the two material elements 9 and 401 in this  
10          embodiment.

An optical effect obtained when the two material  
elements 9 and 401 according to this embodiment are  
used will be described below.

15          For example, assume that the minimum and maximum  
transmission factors of the material element 9 are  
represented by  $A_{MIN}$  and  $A_{MAX}$ , and the material element 9  
can adjust the passing light amount (transmission light  
amount) within a range from the minimum transmission  
factor  $A_{MIN}$  to the maximum transmission factor  $A_{MAX}$ . At  
20          this time, the minimum and maximum transmission factors  
 $A_{MIN}$  and  $A_{MAX}$  satisfy the following relation:

$$0 < A_{MIN} < A_{MAX} < 1 \quad \dots(1)$$

A ratio (light amount ratio) R1 between the maximum  
transmission factor  $A_{MAX}$  to the minimum transmission  
25          factor  $A_{MIN}$  is given by:

$$R1 = A_{MAX}/A_{MIN} \quad (> 1) \quad \dots(2)$$

1 Similarly, the same for the material element 9  
applies to the material element 401. For example,  
assume that the minimum and maximum transmission  
factors of the material element 401 are represented by  
5  $B_{MIN}$  and  $B_{MAX}$ , and the material element 401 can adjust the  
passing light amount (transmission light amount) within  
a range from the minimum transmission factor  $B_{MIN}$  to the  
maximum transmission factor  $B_{MAX}$ . At this time, the  
minimum and maximum transmission factors  $B_{MIN}$  and  $B_{MAX}$   
10 satisfy the following relation:

$$0 < B_{MIN} < B_{MAX} < 1 \quad \dots(3)$$

A ratio (light amount ratio)  $R_2$  between the maximum  
transmission factor  $B_{MAX}$  to the minimum transmission  
factor  $B_{MIN}$  is given by:

15 
$$R_2 = B_{MAX}/B_{MIN} \quad (> 1) \quad \dots(4)$$

The transmission factor (the adjustment range of  
the passing light amount) of the optical system upon  
synthesis of the material elements 9 and 401 ranges  
from  $A_{MIN} \cdot B_{MIN}$  to  $A_{MAX} \cdot B_{MAX}$ .

20 A ratio (light amount ratio)  $R$  of the maximum  
transmission factor to the minimum transmission factor  
is given by:

$$\begin{aligned} R &= (A_{MAX} \cdot B_{MAX}) / (A_{MIN} \cdot B_{MIN}) \\ &= (A_{MAX}/A_{MIN}) \cdot (B_{MAX}/B_{MIN}) \\ &= R_1 \cdot R_2 \quad \dots(5) \end{aligned}$$

25

As can be apparent from equation (5), the value of the  
light amount ratio  $R$  is larger by  $R_2$  ( $B_{MAX}/B_{MIN} (> 1)$ )



1 times than that obtained by, e.g., the material element  
9 alone.

That is, the passing light amount adjustment using  
a plurality of material elements can make the light  
5 amount adjustment range wider than that using the  
material element 9 alone.

In this embodiment, as described above, the two  
material elements 9 and 401 are arranged in the optical  
path of the optical system to widen the passing light  
10 amount adjustment range, thereby obtaining desired  
optical performance.

Note that the two material elements 9 and 401 in  
this embodiment may have either the same or different  
characteristics (transmission factor), and the present  
15 invention can be applied to either case.

In this embodiment, the two material elements 9  
and 401 are arranged to sandwich the optical members  
(the lenses 1a, 1b1, and 1b2) therebetween. However,  
the present invention is not limited to these  
20 arrangement positions. For example, the two material  
elements 9 and 401 may be arranged adjacent to each  
other. The number of material elements is not limited  
to two, but three or more material elements may be  
used. Then, the passing light amount can be adjusted  
25 within a still wider range.

1 (20th Embodiment)

Figs. 43A and 43B are a side view and a front view of one of a plurality of material elements according to the 20th embodiment of the present invention.

5 In this embodiment, a difference from the 19th embodiment is that at least one of two material elements is arranged near an iris position of an optical system, a region of the material element at that time is divided into a plurality of concentric regions, and the transmission factor of at least one of  
10 the divided regions can be adjusted independently of the other regions. Other arrangements and optical effects are substantially the same as those in the 19th embodiment.

15 More specifically, in this embodiment, one material element (represented by reference numeral 402 in this case) is divided into a plurality of concentric pattern regions 402a to 402g, as shown in Fig. 43B (although the element is divided into seven regions in  
20 this embodiment, the present invention is not limited to this number of divided regions) and the transmission factors of the divided regions 402a to 402g are independently adjusted, as shown in, e.g., Figs. 44A to 44H, thus satisfactorily obtaining a stopped-down  
25 effect (e.g., to obtain a desired image by increasing/decreasing the depth of field).

1 Referring to Figs. 44A to 44H, hatched regions  
have a smaller transmission factor than that of the  
other regions. The material element 402 is  
independently controlled in units of regions 402a to  
5 402g, so that the transmission factor is sequentially  
decreased (the depth of field is sequentially  
increased) from Fig. 44A toward Fig. 44H. In this  
manner, the depth of field is increased/decreased to  
obtain an iris effect.

10 (21st Embodiment)

Fig. 45 is a side view showing a light amount  
adjustment device using material elements according to  
the 21st embodiment of the present invention. Fig. 45  
shows a mounting portion of the material element.

15 In this embodiment, a difference from the 19th  
embodiment is that a light amount adjustment device is  
constituted as a unit by forming material elements 422  
and 423 respectively on a light incident surface 421a  
and a light exit surface 421b of a transparent  
20 substrate 421 consisting of, e.g., glass, and the unit  
is arranged at an arbitrary position in the optical  
path of the optical system. Other arrangements and  
optical effects are substantially the same as those in  
the 19th embodiment.

25 More specifically, since one material element 422  
of the two material elements 422 and 423 is formed on  
the light incidence surface 421a of the transparent

1 substrate 421, and the other material element 423 is  
formed on the light exit surface 421b, the same effect  
as in the 19th embodiment can be obtained, and the  
light amount adjustment apparatus can be constituted as  
5 a unit, thereby realizing a simple, compact structure  
of the entire device.

Note that at least one of the two material  
elements 422 and 423 may be divided into a plurality of  
concentric regions, as shown in Figs. 43A and 43B  
10 illustrating the 20th embodiment, and the passing light  
amounts of the plurality of divided regions may be  
independently adjusted. Thus, the iris effect can be  
obtained as in the 20th embodiment described above.  
(22nd Embodiment)

15 Figs. 46A and 46B are a side view and a front view  
of a light amount adjustment device according to the  
22nd embodiment of the present invention.

In this embodiment, a difference from the 21st  
embodiment described above is that a material element  
20 426 is formed only on a region 428 outside the area  
(hatched region) of a circle 427 having the optical  
axis as the center on at least one surface of a  
transparent substrate 424. Other arrangements and  
optical effects are substantially the same as those in  
25 the 21st embodiment described above.

For example, when the passing light amount of an  
optical system is to be adjusted using two material

1 elements each having a not so large maximum  
transmission factor, the maximum transmission factor of  
the optical system may often be considerably lowered.  
For example, when two material elements each having a  
5 maximum transmission factor of 90% are used, the  
synthesized maximum transmission factor of the optical  
system is about 81%. However, when two material  
elements each having a maximum transmission factor of  
50% are used, the synthesized maximum transmission  
10 factor of this optical system is undesirably lowered to  
about 25%.

Thus, in this embodiment, as shown in Figs. 46A  
and 46B, a material element 425 is formed on  
substantially the entire light incident surface 424a of  
the transparent substrate 424 consisting of, e.g.,  
15 glass as in the 21st embodiment, and the material  
element 426 is formed only on the region 428 outside  
the area (~~hatched~~ *hatched* region) of the circle 427 having the  
optical axis as the center on a light exit surface  
20 424b, thereby increasing the passing light amount.

Thus, even when a plurality of material elements  
having low maximum transmission factors are used, the  
synthesized maximum transmission factor can be  
prevented from being considerably lowered. Also, the  
25 passing light amount adjustment range can be widened to  
some extent. Furthermore, a certain iris effect can be  
obtained by the material element 426.

1           Note that the area of the circle 427 on the light  
exit surface 424b on which no material element is  
formed can be arbitrarily set in accordance with the  
characteristics (transmission factor) of a material  
5           element to be used.

          In this embodiment as well, the material element  
425 may be divided into a plurality of concentric  
regions, and the passing light amounts of the divided  
regions may be independently adjusted like in the 20th  
10          embodiment described above. Alternatively, the  
material element 426 may be divided into a plurality of  
regions having concentric circular patterns having the  
optical axis as the center, and the passing light  
amounts of the divided regions may be independently  
15          adjusted.

          In this embodiment, the two material elements 425  
and 426 are integrally formed on the light incident  
surface 424a and the light exit surface 424b of the  
transparent substrate 424. However, the present  
20          invention is not limited to this. For example, the  
material elements 425 and 426 may be arranged at  
different positions as in the 19th embodiment.  
(23rd Embodiment)

          Fig. 47 is a schematic sectional view of the 23rd  
25          embodiment wherein the present invention is applied to  
a video camera. The same reference numerals in Fig. 47  
denote the same parts as in Fig. 42.

1           In this embodiment, a difference from the 19th  
embodiment described above is that material elements  
are formed on a plurality of surfaces of light incident  
surfaces and light exit surfaces of optical members  
5           constituting the photographing optical system 1, such  
as a plurality of lenses, an optical lowpass filter  
437, a protection glass for protecting the image pickup  
element 10, and the like. Other arrangements and  
optical effects are substantially the same as those in  
10          the 19th embodiment described above.

          More specifically, in this embodiment, the  
material element 9 is formed on the light exit surface  
of the stationary lens 1c, and the material element 401  
is formed on the light incident surface of the optical  
15          lowpass filter 437. In addition to the same effect as  
in the 19th embodiment described above, a light amount  
adjustment device can be rendered compact, and the  
entire optical system can also be rendered compact.

          In each of the above embodiments, the present  
20          invention is applied to a video camera. However, the  
present invention is not limited to the video camera,  
but may be similarly applied to any other optical  
systems such as an optical system of a still camera  
using a silver chloride film as in the above  
25          embodiments.

          According to the above embodiments, when a  
plurality of material elements capable of arbitrarily

1 adjusting the transmission factor are arranged in the  
optical path of the optical system, as described above,  
an optical system having a compact light adjustment  
device, which can obtain a wider light amount  
5 adjustment range by a simple arrangement, and can  
obtain a sufficient iris effect, can be realized.  
(24th Embodiment)

The 24th embodiment according to the present  
invention will be described below.

10 As described above, in recent years, in order to  
realize a compact optical system, it has been proposed  
that the transmission light amount of the optical  
system is adjusted using a material element such as a  
liquid crystal element, an electrochromic (EC) element,  
15 or the like in place of an iris device for mechanically  
adjusting the aperture area of an iris aperture  
portion. When the transmission light amount of the  
optical system is adjusted using an iris device  
consisting of the material element, there have been  
20 proposed a method wherein a material element is  
arranged in concentric circular patterns having the  
optical axis as the center, and light  
transmission/shielding states of these patterns are  
independently controlled to adjust the area of the iris  
25 aperture portion, thereby making the amount of light  
transmitted through the optical system and reaching a  
photoelectric conversion element constant; and a method



1 wherein when the incident light amount to the optical  
system is small, the light transmission factor of a  
material element is increased, and when the light  
incident amount to the optical system is large, the  
5 light transmission factor of the material element is  
decreased, thereby making the amount of light reaching  
the photoelectric conversion element constant.

However, a meter iris used in the iris device for  
mechanically adjusting the iris aperture area in a  
10 conventional video camera requires a long period of  
time when the iris aperture area changes from a "0"  
state (close state) to a full-aperture state (open  
state), and vice versa. When the amount of light  
incident on a video camera optical system changes at a  
15 speed beyond the aperture area adjustment speed of the  
iris device, the video camera suffers from an over or  
under exposure amount. For example, when a user  
quickly goes outdoor from an indoor photographing  
state, an over exposure amount may often be  
20 instantaneously obtained.

Even when the exposure amount of the video camera  
is adjusted using the material element, since a change  
in transmission factor of the material element also  
requires a long period of time, an under or over  
25 exposure state may occur depending on the photographing  
condition as in the iris device for mechanically  
adjusting the aperture area. In particular, at a low

1 temperature, since the light transmission factor change  
speed of the material element is considerably lowered,  
an increase in the frequency of occurrence of under or  
over exposure states of the video camera poses a  
5 serious problem.

This embodiment has as its object to provide a  
video camera, which can perform proper exposure amount  
control free from an under or over exposure state even  
when the amount of light incident on an optical system  
10 changes quickly.

In order to achieve the above object, according to  
this embodiment, there is provided a video camera,  
which has an optical system for forming an object image  
on an image pickup element, and transmission light  
15 amount adjustment means, arranged in an optical path of  
the optical system, for adjusting the transmission  
light amount, comprising light accumulation time  
adjustment means for adjusting a light accumulation  
time of the image pickup element, and exposure amount  
20 control means for, when a change speed of the amount of  
light incident on the optical system becomes larger  
than a light amount change speed corresponding to an  
adjustment limit of the transmission light amount  
adjustment means, changing the light accumulation time  
25 of the image pickup element until exposure amount  
adjustment by the transmission light amount adjustment  
means is enabled.

1           Furthermore, the video camera further comprises  
gain adjustment means for adjusting a gain of a video  
signal, and the gain adjustment means can be operated  
together with the exposure amount control means.

5           In order to achieve the above object, there is  
also provided a video camera, which has an optical  
system for forming an object image on an image pickup  
element, and a material element, arranged in an optical  
10          path of the optical system, for adjusting the  
transmission light amount, comprising gain adjustment  
means for adjusting a gain of a video signal, and  
exposure amount control means for changing the gain of  
the video signal in addition to the transmission light  
amount adjustment of the material element until  
15          exposure amount adjustment by the material element  
alone is enabled, under a condition that a change speed  
of the amount of light incident on the optical system  
becomes larger than the light amount change speed  
corresponding to an adjustment light of the material  
20          element.

          On the other hand, the video camera may comprise  
light accumulation time adjustment means for adjusting  
a light accumulation time of the image pickup element,  
and the light accumulation time adjustment means can  
25          adjust the light accumulation time of the image pickup  
element together with the exposure amount control  
means.

1           With the above-mentioned means, the exposure  
amount can be corrected by temporarily adjusting the  
light accumulation time of the image pickup element or  
the gain of the video signal. Even when the aperture  
5   area adjustment speed of an iris mechanism cannot  
follow a quick change in amount of light incident on  
the optical system, such a problem can be temporarily  
compensated for. Therefore, even when the amount of  
light incident on the optical system changes quickly,  
10   proper exposure amount control can be performed, and a  
high-quality image can be obtained.

Fig. 48 is a schematic sectional view showing a  
video camera according to the 24th embodiment of the  
present invention. Since the circuit arrangement of  
15   this embodiment is the same as that shown in the block  
diagram of Fig. 2 in the first embodiment, and  
operation control is the same as that shown in the flow  
chart of Fig. 4, a detailed description thereof will be  
omitted.

20           Referring to Fig. 48, a photographing optical  
system is constituted by a focus lens 1a, zoom lenses  
1b, and a stationary lens 1c. The focus lens 1a is  
held by a focus lens holding frame 2, which has a gear  
portion 2a. A stationary portion 3 is threadably  
25   engaged with the focus lens holding frame 2.  
Furthermore, a cam cylinder 4 has a cam groove for  
determining the positions of the zoom lenses 1b, and is

1 rotatably held by the stationary portion 3. The zoom  
lenses 1b are held by lens frames 5 and 6.

5 The focus lens holding frame 2 is pivoted by a  
focus motor 7. A gear 7a attached to the rotational  
shaft of the motor 7 is engaged with the gear portion  
2a. The cam cylinder 4 is pivoted by a zoom motor 8.  
A gear 8a is attached to the rotational shaft of the  
motor 8. Note that the gear 8a is engaged with a gear  
portion 4a of the cam cylinder 4. A galvano iris 500  
10 is used for adjusting the transmission light amount of  
the photographing optical system.

20 An image pickup element 10 employs a photoelectric  
conversion element such as a CCD. The photographing  
optical system has an optical axis 11. An electronic  
viewfinder 12 has an eyepiece lens 13. Furthermore,  
15 the camera includes a power switch 14, and a zoom  
operation member 15. The camera also includes a camera  
control circuit 21, and a recording unit 18 and a power  
source 19, which are electrically connected to the  
camera control circuit 21. The camera control circuit  
21 is electrically connected to the focus motor 7, the  
zoom motor 8, the galvano iris 500, the image pickup  
element 10, the electronic viewfinder 12, the power  
switch 14, and the zoom operation member 15. Note that  
25 an effective light beam 16 is indicated by an alternate  
long and two short dashed line.

1           An exposure amount control operation will be  
described below with reference to Figs. 49A and 49B.  
Fig. 49B shows processing following Fig. 49A.

5           When the exposure amount adjustment operation is  
started, the light accumulation time of the image  
pickup element (CCD) 10 is set in a standard state  
(S401). In this state, if the incident light amount on  
the image pickup element 10 is proper (S402), the  
aperture size of the galvano iris 500 is maintained  
10 (S403). However, if the incident light amount on the  
image pickup element 10 is too much (S404), an iris  
closing operation of the galvano iris 500 is started  
(S405, S406). At this time, if the excess amount of  
the incident light amount on the image pickup element  
15 10 decreases (S407), light amount adjustment using the  
galvano iris 500 is continued. However, if the excess  
amount does not change or increases, the light  
accumulation time of the image pickup element 10 is  
gradually shortened (S408, S409) in addition to the  
20 light amount adjustment using the galvano iris 500, so  
that the exposure amount approaches a proper value.  
When the incident light amount reaches or becomes close  
to the proper exposure amount (S410, S411), the light  
accumulation time of the image pickup element 10 is  
25 gradually prolonged (S412), and is then restored to the  
standard state (S413).

1           When the incident light amount on the image pickup  
element 10 runs short (S404, S414), an iris opening  
operation of the galvano iris 500 is started (S415).  
If the shortage amount of the incident light amount on  
5 the image pickup element 10 decreases, the light amount  
adjustment using the galvano iris 500 is continued.  
However, if the shortage amount does not change or  
increases (S416), the light accumulation time of the  
image pickup element 10 is prolonged up to a limit  
10 value (S417, S418, S419) in addition to the light  
amount adjustment using the galvano mirror 9, so that  
the exposure amount approaches a proper value. When  
the incident light amount reaches or becomes close to a  
proper exposure amount (S420), the light accumulation  
15 time of the image pickup element 10 is gradually  
shortened (S421, S422), and is restored to the standard  
state. When the exposure amount runs short (S423), it  
is checked if the light accumulation time is equal to  
or larger than a limit value (S419). If it is  
20 determined that the light accumulation time is equal to  
or larger than a limit value, the light accumulation  
time is fixed at a limit value (S424).

          Figs. 50A and 50B are flow charts showing the  
second example of an exposure amount control operation.  
25 Although the flow chart of Fig. 50A is followed by the  
flow chart of Fig. 50B, since the flow chart of  
Fig. 50B is the same as that of Fig. 49B, a detailed

1 description thereof will be omitted. Also, since steps  
of executing the same processing as in Fig. 49A are  
denoted by the same reference numerals in the flow  
chart of Fig. 50A, a repetitive description thereof  
5 will be avoided.

The gain of the image pickup element 10 is set in  
a standard state (S601), and the light accumulation  
time of the image pickup element 10 is set in the  
standard state (S401). In this state, if the incident  
10 light amount on the image pickup element 10 is proper,  
the aperture size of the galvano iris 500 is maintained  
(S602). Furthermore, gain adjustment of a video signal  
is stopped (S603), and the gain of the video signal is  
set in the standard state (S604). Thereafter, the flow  
15 returns to step S401, and the subsequent processing is  
repetitively executed. If it is determined in step  
S402 that the incident light amount is improper, it is  
checked in step S404 if the incident light amount is  
too much, as has been described above with reference to  
20 Fig. 49A. If it is determined in step S404 that the  
incident light amount is too much, processing in steps  
S405 to S407 is executed. If it is determined in step  
S407 that M does not decrease, adjustment of gain  
reduction of the video signal is started, and the flow  
25 continues to node ④ in Fig. 49B. Similarly, if it is  
determined in step S404 that the incident light amount  
runs short, processing in steps S414 to S416 is



1 executed. If it is determined in step S416 that N does  
not decrease, adjustment of gain increment of the video  
signal is started, and the flow continues to node ⑧ in  
Fig. 49B. Since processing in Fig. 50B is the same as  
5 that shown in Fig. 49B, a detailed description thereof  
will be omitted.

Fig. 51 is a schematic sectional view showing  
another arrangement of a video camera according to the  
present invention. Since the same reference numerals  
10 in Fig. 51 denote the same parts as in Fig. 48, a  
repetitive description thereof will be avoided here.  
Also, since the circuit block diagram showing a control  
system of this embodiment, and the flow chart showing  
the operation of the control circuit are the same as  
15 those in Figs. 2 and 4 of the first embodiment, a  
detailed description thereof will be omitted.

This embodiment is characterized in that a  
material element 501 comprising, e.g., an  
electrochromic (EC) element, a liquid crystal element,  
20 or the like capable of adjusting the transmission light  
amount is arranged in the optical path of the  
photographing optical system. The material element 501  
is electrically connected to the camera control circuit  
21.

25 The exposure amount control operation of the  
embodiment shown in Fig. 51 will be described below  
with reference to the flow charts of Figs. 52A and 52B

1 (for explaining the exposure amount control operation).  
Although processing in Fig. 52A is followed by  
processing shown in Fig. 52B, the processing shown in  
Fig. 52B is the same as that in Fig. 49B, a description  
5 thereof will be omitted. Since the same reference  
numerals in Figs. 52A and 52B denote the same steps as  
in Figs. 49A and 49B, a repetitive description thereof  
will be avoided here.

When the light amount adjustment operation is  
10 started, the light accumulation time of the image  
pickup element 10 is set in the standard state (S401).  
In this state, it is checked if the incident light  
amount on the image pickup element 10 is proper (S402).  
If it is determined that the incident light amount is  
15 proper, the current light transmission factor (or light  
transmission amount) of the material element 501 is  
maintained (S801), and the flow returns to step S401.  
However, if the incident light amount on the image  
pickup element 10 is too much, processing for  
20 increasing the light transmission factor of the  
material element 501 is executed in step S404 and  
subsequent steps.

In this case, if the excess amount of the image  
pickup element 10 decreases (S404), light amount  
25 adjustment using the material element 501 is continued.  
However, if the excess amount does not change or  
increases, the light accumulation time of the image

1 pickup element 10 is shortened in addition to the light  
amount adjustment using the material element 501, so  
that the exposure amount approaches a proper value  
(S405, S802, S407). When the incident light amount  
5 reaches or becomes close to a proper exposure amount,  
the light accumulation time of the image pickup element  
10 is prolonged, and is restored to the standard state.

On the other hand, when the incident light amount  
on the image pickup element 10 runs short, an operation  
10 for decreasing the light transmission factor of the  
material element 501 is executed (S414, S803, S416).  
At this time, when the shortage amount of the incident  
light amount decreases, light amount adjustment using  
the material element 501 is continued. However, when  
15 the shortage amount does not change or increases, the  
light accumulation time of the image pickup element 10  
is prolonged up to its limit value in addition to the  
light amount adjustment using the material element 501,  
so that the exposure amount approaches a proper value.  
20 When the light incident amount reaches or becomes close  
to a proper exposure amount, the light accumulation  
time of the image pickup element 10 is shortened, and  
is restored to the standard state.

Fig. 53 is a flow chart showing the second example  
25 of exposure amount control processing corresponding to  
the embodiment shown in Fig. 51. Since the same  
reference numerals in Fig. 53 denote the same steps as

1 in the above-mentioned flow charts, a repetitive description thereof will be avoided here.

When the exposure amount adjustment operation is started, the gain of the image pickup element 10 is set  
5 in the standard state (S601). In this state, it is checked if the incident light amount on the image pickup element 10 is proper (S402). If the incident light amount is proper, the light transmission factor (or light transmission amount) of the material element  
10 501 is maintained (S901). Furthermore, gain adjustment of a video signal is stopped (S902), and the gain of the video signal is set in the standard state (S903).

However, if the incident light amount on the image pickup element 10 is too much, processing for  
15 decreasing the light transmission factor of the material element 501 is executed in step S404 and subsequent steps. If the excess amount of the incident light amount on the image pickup element 10 decreases, light amount adjustment using the material element 501  
20 is continued. However, if the excess amount does not change or increases (S404), the gain of the video signal is decreased (S904) in addition to light amount adjustment using the material element 501 (S405, S406), so that the exposure amount approaches a proper value.  
25 When the incident light amount reaches or becomes close to a proper exposure amount, the gain of the video signal is restored to the standard state.

1        On the other hand, if the incident light amount on  
the image pickup element 10 runs short, processing for  
increasing the light transmission factor of the  
material element 501 is executed. At this time, if the  
5 shortage amount of the incident light amount on the  
image pickup element 10 decreases, light amount  
adjustment using the material element 501 is continued  
(S414, S415). However, if the shortage amount does not  
change or increases (S416), the gain of the video  
10 signal is increased (S905) in addition to light amount  
adjustment using the material element 501, so that the  
exposure amount approaches a proper value. Then, when  
the incident light amount reaches or becomes close to a  
proper exposure amount, the gain of the video signal is  
15 restored to the standard state.

      Figs. 54A and 54B are flow charts showing the  
third example of exposure amount control processing  
corresponding to the embodiment shown in Fig. 51.  
Since the same reference numerals in Fig. 54A denote  
20 the same steps as in the above-mentioned flow charts, a  
repetitive description thereof will be avoided here.  
More specifically, in the flow chart of Fig. 53, if it  
is determined in step S402 that the incident light  
amount is not proper, processing in step S404 and  
25 subsequent steps is executed, and then, processing in  
steps S904 and S905 is executed to perform gain  
adjustment of the video signal. Thereafter, the flow

1 returns to step S402. However, in the flow charts  
shown in Figs. 54A and 54B of this embodiment, the flow  
advances to processing shown in Fig. 54B. The  
processing in Fig. 54B is the same as that shown in  
5 Fig. 49B, and a detailed description thereof will be  
omitted. That is, in Fig. 54B, the light accumulation  
time is controlled.

In each of the above embodiments, the light  
transmission amount is adjusted by the material element  
10 501. In this case, the light transmission amount of  
the optical system may be adjusted by changing the  
density of the entire material element. Alternatively,  
the material element may have a predetermined pattern,  
as shown in Fig. 55, and the light transmission amount  
15 of the optical system may be adjusted by changing the  
transmission factors of the pattern regions, as shown  
in Figs. 56A to 56H, or the light transmission amount  
of the optical system may be adjusted by independently  
controlling the densities of the pattern regions.

20 Also, transmission factor detection means for the  
material element 501 may be arranged to detect the  
transmission factor or transmission factor change speed  
of the material element. When the incident light  
amount to the optical system changes at a speed beyond  
25 the incident light amount adjustment capacity of the  
material element 501, exposure control may be made  
using the present invention. Furthermore, when the

1 incident light amount to the optical system changes  
rapidly, and the material element 501 cannot perform  
incident light amount adjustment even after an elapse  
of a predetermined period of time, exposure adjustment  
5 according to the present invention may be executed.

Moreover, the transmission light amount adjustment  
speed of the material element 501 is normally lowered  
in a low-temperature environment. For this reason, a  
video camera using the material element 501 in  
10 transmission light amount adjustment may be provided  
with temperature detection means, and when the incident  
light amount to the optical system changes quickly in a  
low-temperature environment, exposure adjustment  
according to the present invention may be executed.

15 Since this embodiment has the above-mentioned  
arrangement, it can provide the following effects.

A video camera having an optical system for  
forming an object image on an image pickup element, and  
transmission light amount adjustment means, arranged in  
20 an optical path of the optical system, for adjusting a  
transmission light amount, comprises light accumulation  
time adjustment means for adjusting a light  
accumulation time of the image pickup element, and  
exposure amount control means for, when the change  
25 speed of an incident light amount to the optical system  
exceeds a light amount change speed corresponding to an  
adjustment limit of the transmission light amount

1 adjustment means, changing the light accumulation time  
of the image pickup element until exposure amount  
adjustment of the transmission light amount adjustment  
means is enabled. Therefore, even when the incident  
5 light amount to the optical system changes quickly,  
proper exposure amount control can be performed, and a  
high-quality image can be obtained.

Since the video camera also comprises gain  
adjustment means for adjusting the gain of a video  
10 signal, and the gain adjustment means is operated  
together with the exposure amount control means, finer  
exposure amount control can be realized.

Also, a video camera having an optical system for  
forming an object image on an image pickup element, and  
15 a material element, arranged in an optical path of the  
optical system, for adjusting a transmission light  
amount, comprises gain adjustment means for adjusting  
the gain of a video signal, and exposure amount control  
means for changing the gain of the video signal in  
20 addition to transmission light amount adjustment of the  
material element, under a condition that a change speed  
of the incident light amount to the optical system  
exceeds a light amount change speed corresponding to an  
adjustment limit of the material element. Therefore,  
25 even when the incident light amount to the optical  
system changes fast, proper exposure amount control can  
be performed, and a high-quality image can be obtained.



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1 WHAT IS CLAIMED IS:

*Sub R*  
1. A video camera comprising:  
a material element, arranged in a photographing  
optical system, for controlling a light transmission  
5 factor or a light transmission amount;  
photoelectric conversion means for receiving an  
optical image transmitted through said material element  
at a position of an imaging plane, and converting the  
optical image into an electrical image signal; and  
10 correction means for correcting light transmission  
factor wavelength dependency of said material element  
in accordance with light transmission factor  
characteristics or light transmission amount  
characteristics of said material element.

15  
2. A video camera according to claim 1, wherein  
said correction means adjusts a correction amount of  
the light transmission factor wavelength dependency in  
accordance with the light transmission factor or the  
20 light transmission amount of said material element.

*AC*  
*G*  
I. 3. A ~~video~~ *by* camera according to claim 1, wherein  
~~the correction of~~ *Corrects said change* said correction means ~~is achieved~~  
*of* by  
auto white-balance control ~~for~~ an output signal from  
25 said photoelectric conversion means.

*a G* <sup>11</sup> 4. A ~~video~~ camera according to claim 1, wherein <sup>by</sup> ~~the correction of said correction means~~ <sup>corrects said change</sup> ~~is achieved~~ by changing a sensitivity of said photoelectric conversion means in accordance with a light wavelength.

<sup>5</sup> ~~Sub A~~ 5. A video camera according to claim 1, wherein the correction of said correction means is achieved by a filter provided to said photographing optical system or said photoelectric conversion means.

<sup>10</sup> *a G* <sup>I</sup> 6. A ~~video~~ camera according to claim 1, wherein <sup>by</sup> ~~the correction of said correction means~~ <sup>corrects said change</sup> ~~is achieved~~ by <sup>physical</sup> ~~arranging another material element~~ capable of controlling a light transmission factor in ~~said~~ <sup>the</sup> photographing optical system.

<sup>15</sup> ~~Sub A~~ 7. A video camera according to claim 1, wherein said correction means comprises storage means for storing the light transmission factor wavelength dependency of said material element or the correction amount of the light transmission factor wavelength dependency of said material element.

<sup>25</sup> 8. A video camera according to claim 7, wherein said storage means stores a plurality of light transmission factor wavelength dependencies or a plurality of correction amounts in accordance with the

1 light transmission factor or the light transmission  
amount of said material element.

9. A video camera comprising:

5 a material element, arranged in a photographing  
optical system, for controlling a light transmission  
factor or a light transmission amount;

photoelectric conversion means for receiving an  
optical image transmitted through said material element  
10 at a position of an imaging plane, converting the  
optical image into an electrical image signal, and  
capable of adjusting at least one of a light  
accumulation time and a sensitivity; and

exposure amount adjustment means for adjusting the  
15 light transmission factor or the light transmission  
amount of said material element, and at least one of  
the light accumulation time and the sensitivity of said  
photoelectric conversion means.

20 10. A video camera according to claim 9, wherein  
said exposure amount adjustment means electrically  
adjusts the light transmission factor or the light  
transmission amount of said material element.

25 11. A video camera according to claim 9, wherein  
said exposure amount adjustment means adjusts the light  
transmission factor or the light transmission amount of

1 said material element in accordance with incident  
light.

12. A video camera according to claim 9, wherein  
5 said exposure amount adjustment means comprises storage  
means for storing at least one relationship between the  
light transmission factor or the light transmission  
amount of said material element and the light  
accumulation time or the sensitivity of said  
10 photoelectric conversion means.

13. A video camera having a photographing optical  
system consisting of an optical element such as a  
photographing lens, and image pickup means, wherein a  
15 material element capable of controlling a light  
transmission factor is arranged in one of said optical  
element and said image pickup element.

14. A video camera according to claim 13, wherein  
20 said material element is formed on said optical  
element.

15. A video camera according to claim 13, wherein  
said material element is held by an optical element  
25 holding member of said photographing optical system.

1        16. A camera, which has a photographing optical  
system, a material element, having polarization means,  
for controlling a transmission light factor or a  
transmission light amount of said photographing optical  
5 system, light reflection means, and photoelectric  
conversion means arranged on an imaging plane of said  
photographing optical system or on a plane optically  
equivalent to the imaging plane, comprising: circularly  
polarizing light conversion means arranged on a side of  
10 the imaging plane of said material element or on a side  
of the plane optically equivalent to the imaging plane,  
wherein said light reflection means is arranged between  
said photoelectric conversion means and said circularly  
polarizing light conversion means.

15

17. A camera according to claim 16, wherein said  
material element and said circularly polarizing light  
conversion means are integrally arranged.

20        18. A camera, which has a photographing optical  
system, a material element, having polarization means,  
for controlling a transmission light factor or a  
transmission light amount of said photographing optical  
system, light reflection means, and photoelectric  
25 conversion means arranged on an imaging plane of said  
photographing optical system or on a plane optically  
equivalent to the imaging plane, wherein said material

1 element is arranged between the imaging plane and said  
light reflection means.

19. A video camera, which has a photographing  
5 optical system including a material element, having  
polarization means, for controlling a light  
transmission factor or a light transmission amount, and  
an optical lowpass filter, and also has photoelectric  
conversion means arranged on an imaging plane of said  
10 photographing optical system or on a plane optically  
equivalent to the imaging plane, comprising: circularly  
polarizing light conversion means arranged on a side of  
the imaging plane of said material element or on a side  
of the plane optically equivalent to the imaging plane,  
15 wherein said optical lowpass filter is arranged between  
said photoelectric conversion means and said circularly  
polarizing light conversion means.

20. A video camera according to claim 19, wherein  
20 said material element and said circularly polarizing  
light conversion means are integrally arranged.

21. A video camera, which has a photographing  
optical system including a material element, having  
25 polarization means, for controlling a light  
transmission factor or a light transmission amount, and  
an optical lowpass filter, and also has photoelectric

- 1 conversion means arranged on an imaging plane of said  
photographing optical system or on a plane optically  
equivalent to the imaging plane, wherein said material  
element is arranged between said photoelectric  
5 conversion means and said optical lowpass filter.

22. A camera, which has a photographing optical  
system including a material element capable of  
controlling a light transmission factor or a light  
10 transmission amount, and also has photoelectric  
conversion means arranged on an imaging plane of said  
photographing optical system or on a plane optically  
equivalent to the imaging plane, wherein said material  
element has a filter function of removing near infrared  
15 light.

23. A camera, which has a photographing optical  
system including a material element capable of  
controlling a light transmission factor or a light  
20 transmission amount, and also has photoelectric  
conversion means arranged on an imaging plane of said  
photographing optical system or on a plane optically  
equivalent to the imaging plane, wherein said material  
element and a filter for removing near infrared light  
25 are integrally arranged.



1        24. A video camera, which has a photographing  
optical system including a material element capable of  
controlling a light transmission factor, and also has  
photoelectric conversion means arranged on an imaging  
5 plane of said photographing optical system, comprising:  
correction means for correcting light transmission  
factor wavelength dependency characteristics of said  
material element.

10       25. A video camera according to claim 24, further  
comprising storage means for storing the light  
transmission factor wavelength dependency  
characteristics of said material element, which are  
obtained when said material element is in a  
15 predetermined state.

26. A video camera according to claim 25, wherein  
said storage means is storage means for storing a  
plurality of light transmission factor wavelength  
20 dependency characteristics of said material element,  
which are obtained when said material element is in the  
predetermined state.

27. A video camera according to claim 25, further  
25 comprising temperature detection means, and wherein  
said storage means is storage means for storing a  
plurality of light transmission factor wavelength

1 dependency characteristics of said material element  
under a predetermined temperature condition.

28. A video camera, which has a photographing  
5 optical system including a material element capable of  
controlling a light transmission factor or a light  
transmission amount, and also has photoelectric  
conversion means arranged on an imaging plane of said  
photographing optical system, wherein when said  
10 photoelectric conversion means does not perform a  
photoelectric conversion operation, said material  
element is set in a light shielding state, a  
substantially minimum light transmission factor state,  
or a substantially minimum light transmission amount  
15 state.

29. A video camera according to claim 28, wherein  
when a power switch of said video camera is turned off,  
said material element is set in the light shielding  
20 state, substantially the minimum light transmission  
factor state, or substantially the minimum light  
transmission amount state.

30. A video camera according to claim 28, further  
25 comprising reproduction means for reproducing a  
recorded image, and wherein when said video camera is  
set in a reproduction state of the recorded image or in

1 a reproduction mode of the recorded image, said  
material element is set in the light shielding state,  
substantially the minimum light transmission factor  
state, or substantially the minimum light transmission  
5 amount state.

31. A video camera according to claim 28, wherein  
when said photoelectric conversion means does not  
perform a photoelectric conversion operation, voltage  
10 application to said material element is not performed.

32. A video camera according to claim 28, wherein  
when said photoelectric conversion means stops a  
photoelectric conversion operation, said material  
15 element is set in the light shielding state,  
substantially the minimum light transmission factor  
state, or substantially the minimum light transmission  
amount state, and thereafter, voltage application to  
said material element is stopped.

20

33. A video camera according to claim 31, wherein  
when voltage application to said material element is  
not performed, said material element is set in the  
light shielding state, substantially the minimum light  
25 transmission factor state, or substantially the minimum  
light transmission amount state.

1        34. A video camera according to claim 32, wherein  
when voltage application to said material element is  
stopped, the light transmission factor or the light  
transmission amount of said material element is held in  
5 a state obtained when the voltage application to said  
material element is stopped.

35. An optical system having a light amount  
adjustment device, which controls a passing light  
10 amount by arranging a plurality of material elements  
capable of adjusting a transmission factor in an  
optical path of an optical system.

36. An optical system according to claim 35,  
15 wherein a light transmission region of at least one of  
said plurality of material elements is divided into a  
plurality of regions, and a transmission factor of at  
least one of the divided regions can be adjusted  
independently of the other regions.

20 37. An optical system according to claim 36,  
wherein said at least one material element divided into  
the plurality of regions is arranged near an iris  
position of said optical system.

25 38. An optical system according to claim 35,  
wherein an optical element on a light incident surface

1 side and a light exit surface side of which said  
material elements are arranged is arranged in the  
optical path of said optical system.

5 39. An optical system according to claim 38,  
wherein said material element is formed on the entire  
surface of at least one of the light incident surface  
and the light exit surface of said optical element, and  
said material element is formed on only a ring-shaped  
10 region of a circle having an optical axis as a center  
on the other surface.

40. An optical system according to claim 35,  
wherein said material element is formed on at least one  
15 surface of an optical member constituting said optical  
system.

41. An optical system having a light amount  
adjustment device, wherein when a plurality of material  
20 elements capable of adjusting a transmission factor are  
arranged in an optical path of said optical system to  
control a passing light amount, a light transmission  
region of at least one of said plurality of material  
elements is divided into a plurality of regions, and a  
25 transmission factor of at least one of the divided  
regions can be adjusted independently of the other  
regions.

1        42. A video camera, which has an optical system  
for forming an image of an object image on an image  
pickup element, and transmission light amount  
adjustment means, arranged in an optical path of said  
5 optical system, for adjusting a transmission light  
amount, comprising:

light accumulation time adjustment means for  
adjusting a light accumulation time of said image  
pickup element; and

10        exposure amount control means for, when a change  
speed of an incident light amount to said optical  
system exceeds a light amount change speed  
corresponding to an adjustment limit of said  
transmission light amount adjustment means, changing  
15 the light accumulation time of said image pickup  
element until exposure amount adjustment of said  
transmission light amount adjustment means is enabled.

20        43. A video camera according to claim 42, further  
comprising gain adjustment means for adjusting a gain  
of a video signal, and wherein said gain adjustment  
means operates together with said exposure amount  
control means.

25        44. A video camera, which has an optical system  
for forming an image of an object image on an image  
pickup element, and a material element, arranged in an

1 optical path of said optical system, for adjusting a  
transmission light amount, comprising:

gain adjustment means for adjusting a gain of a  
video signal; and

5 exposure amount control means for changing the  
gain of the video signal until exposure amount  
adjustment using said material element alone is enabled  
in addition to transmission light amount adjustment  
using said material element under a condition that a  
10 change speed of an incident light amount to said  
optical system exceeds a light amount change speed  
corresponding to an adjustment limit of said material  
element.

15 45. A video camera according to claim 44, further  
comprising light accumulation time adjustment means for  
adjusting a light accumulation time of said image  
pickup element, and wherein said light accumulation  
time adjustment means adjusts the light accumulation  
20 time of said image pickup element together with said  
exposure amount control means.



1 ABSTRACT OF THE DISCLOSURE

There is disclosed a video camera including a material element, arranged in a photographing optical system, for controlling the light transmission factor or amount, an image pickup element for receiving an optical image transmitted through the material element at the position of an imaging plane, and converting the optical image into an electrical signal, and a correction unit for correcting the light transmission factor wavelength dependency of the material element in accordance with the light transmission factor characteristics or light transmission amount characteristics of the material element.

15

20

25

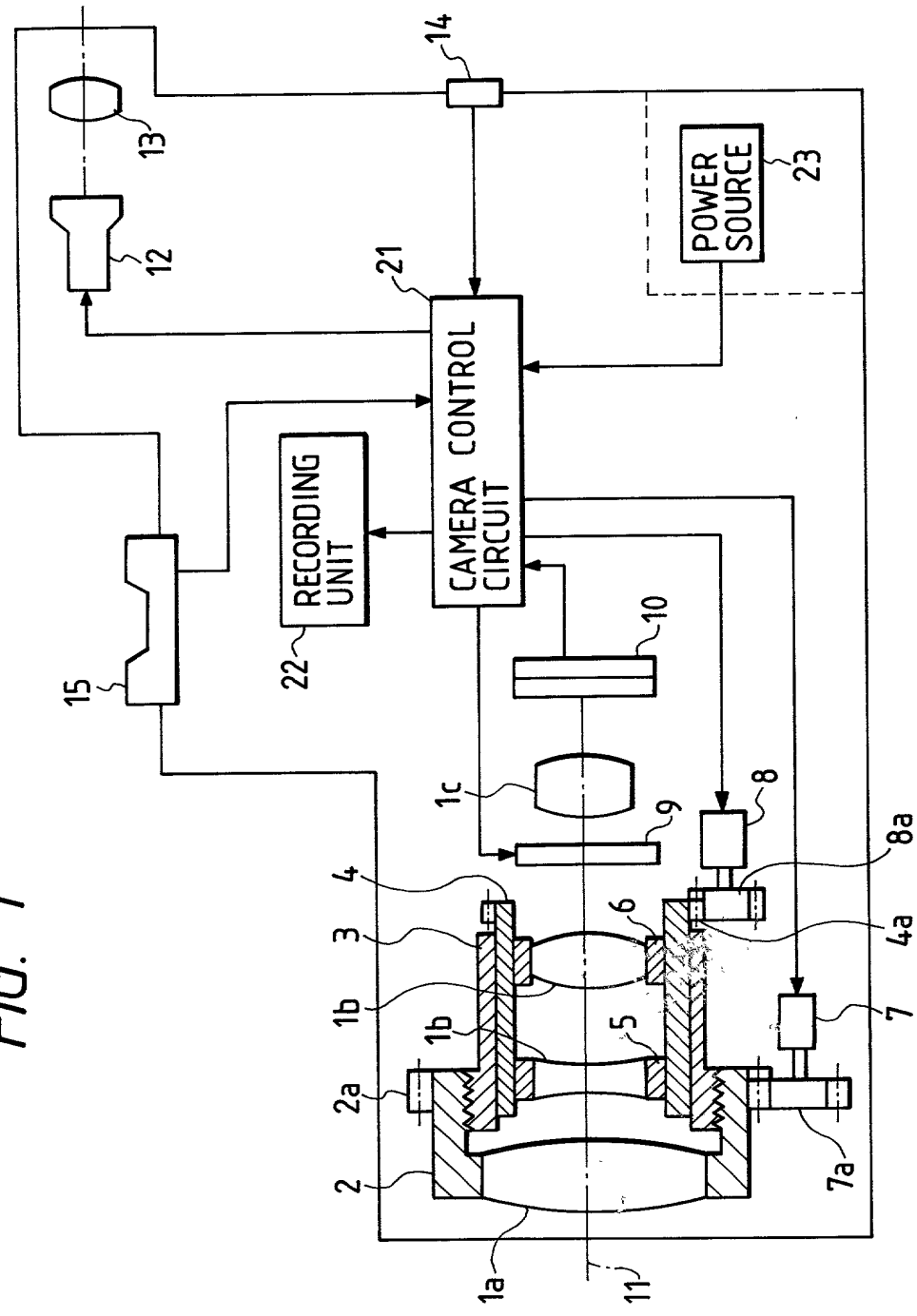
2025 RELEASE UNDER E.O. 14176



APPROVED	O. G. FIG.
BY	CLASS
DRAFTSMAN	SUPCLASS

848243

FIG. 1





APPROVED BY DRAFTSMAN	CLASS	SUBCLASS
	O.G. FIG.	

FIG. 3

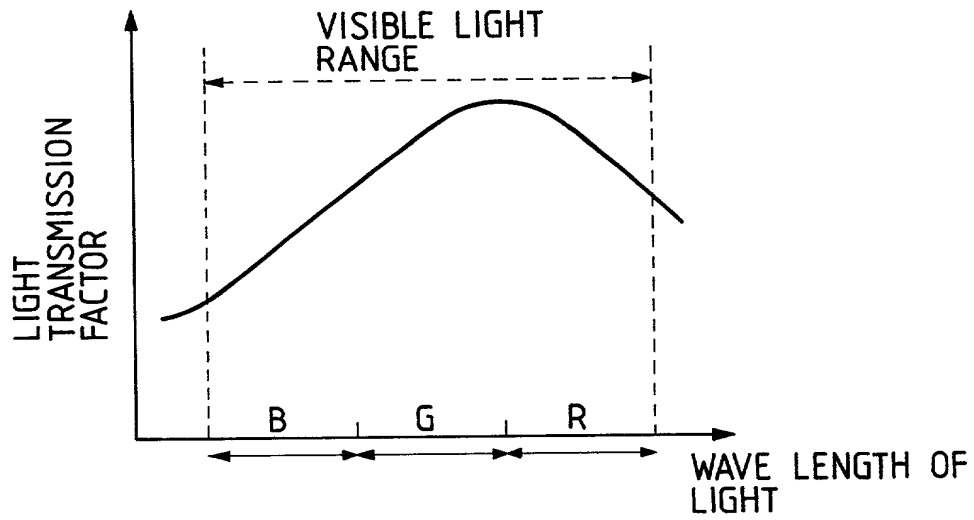
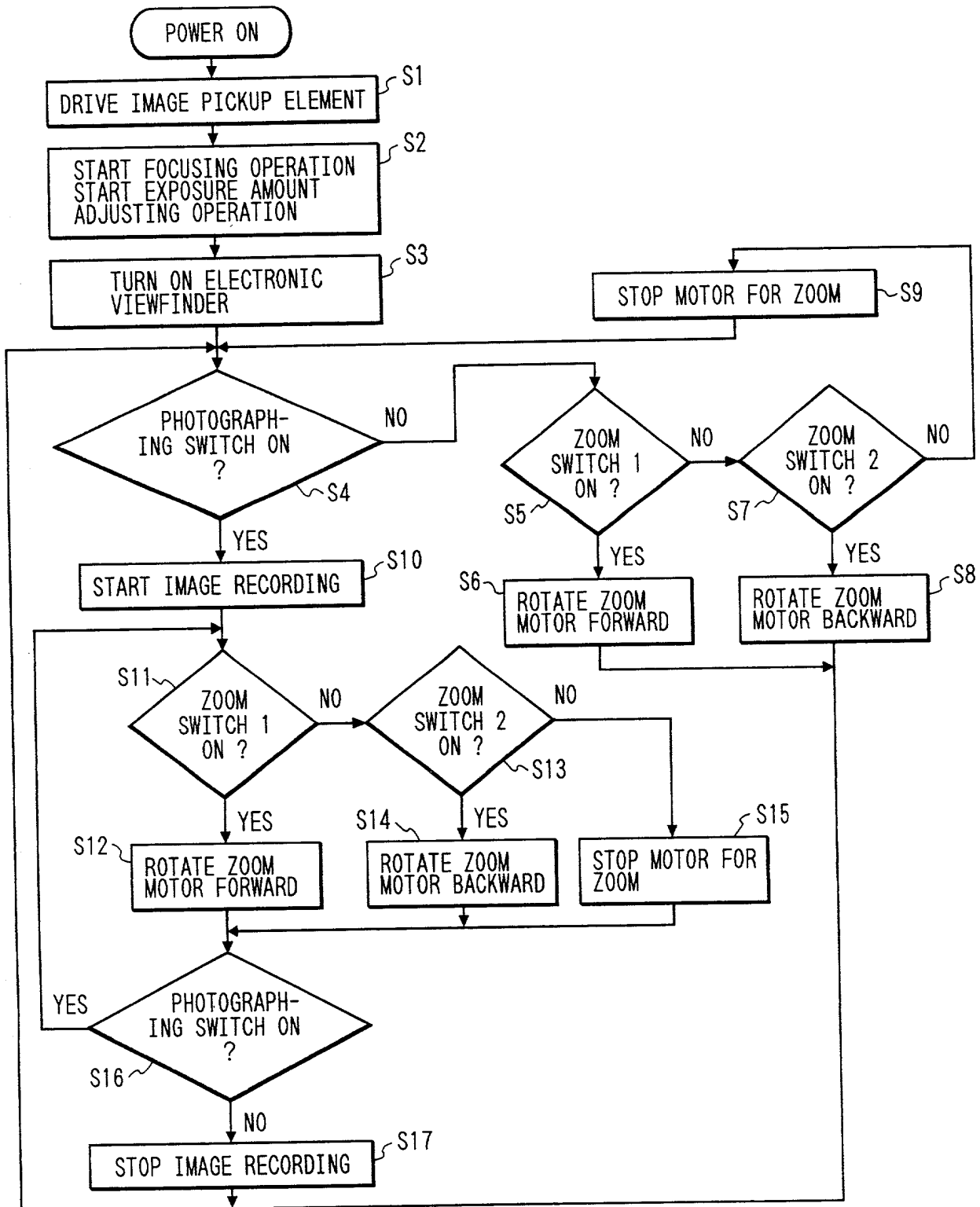


FIG. 7

	Mg	G	Mg	G
	Cy	Ye	Cy	Ye
	Mg	G	Mg	G
	Cy	Ye	Cy	Ye

2025 RELEASE UNDER E.O. 14176

FIG. 4





APPROVED	CLASS	CLASS	CLASS
BY			
DRAFTSMAN			

FIG. 6

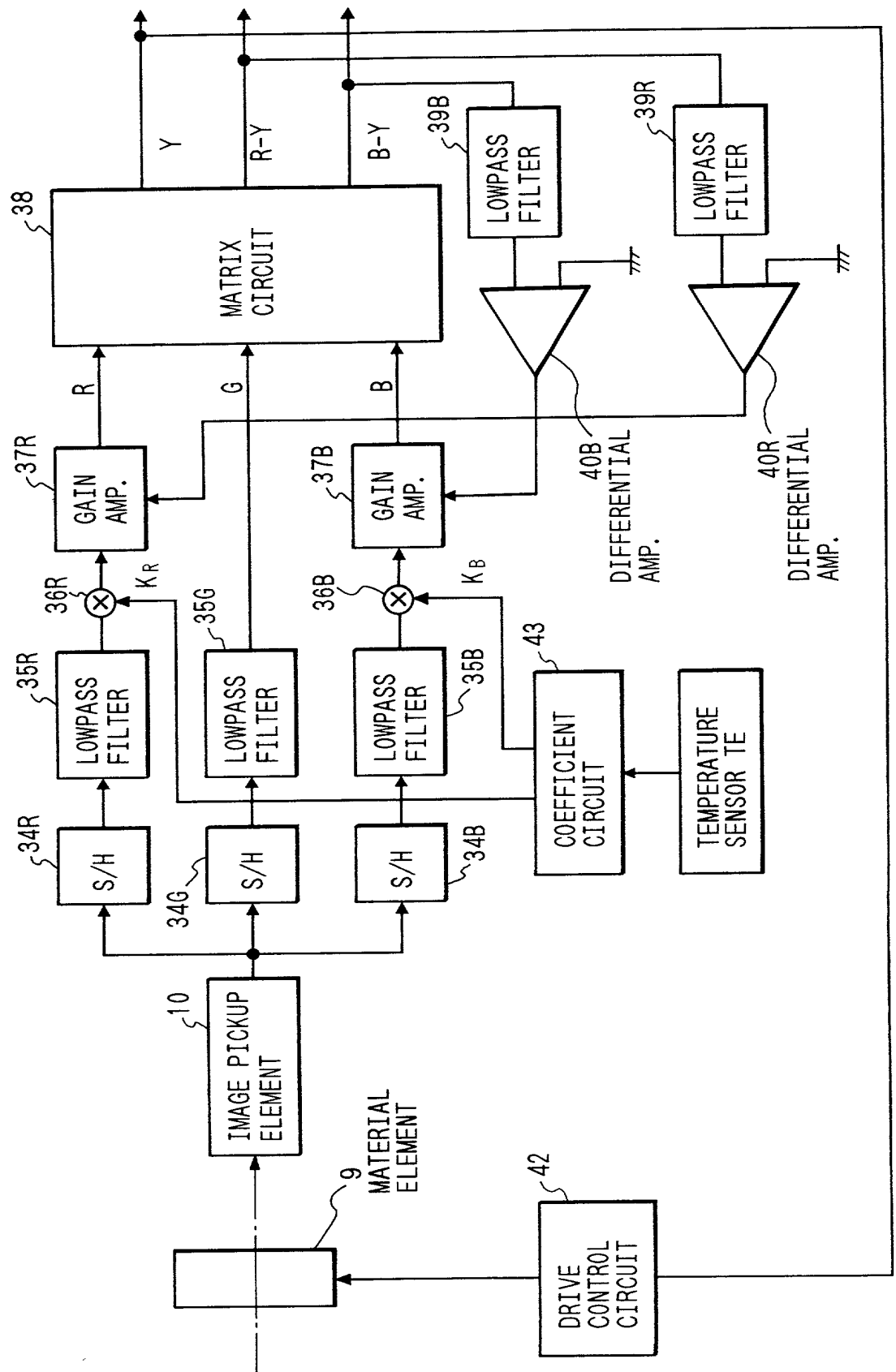
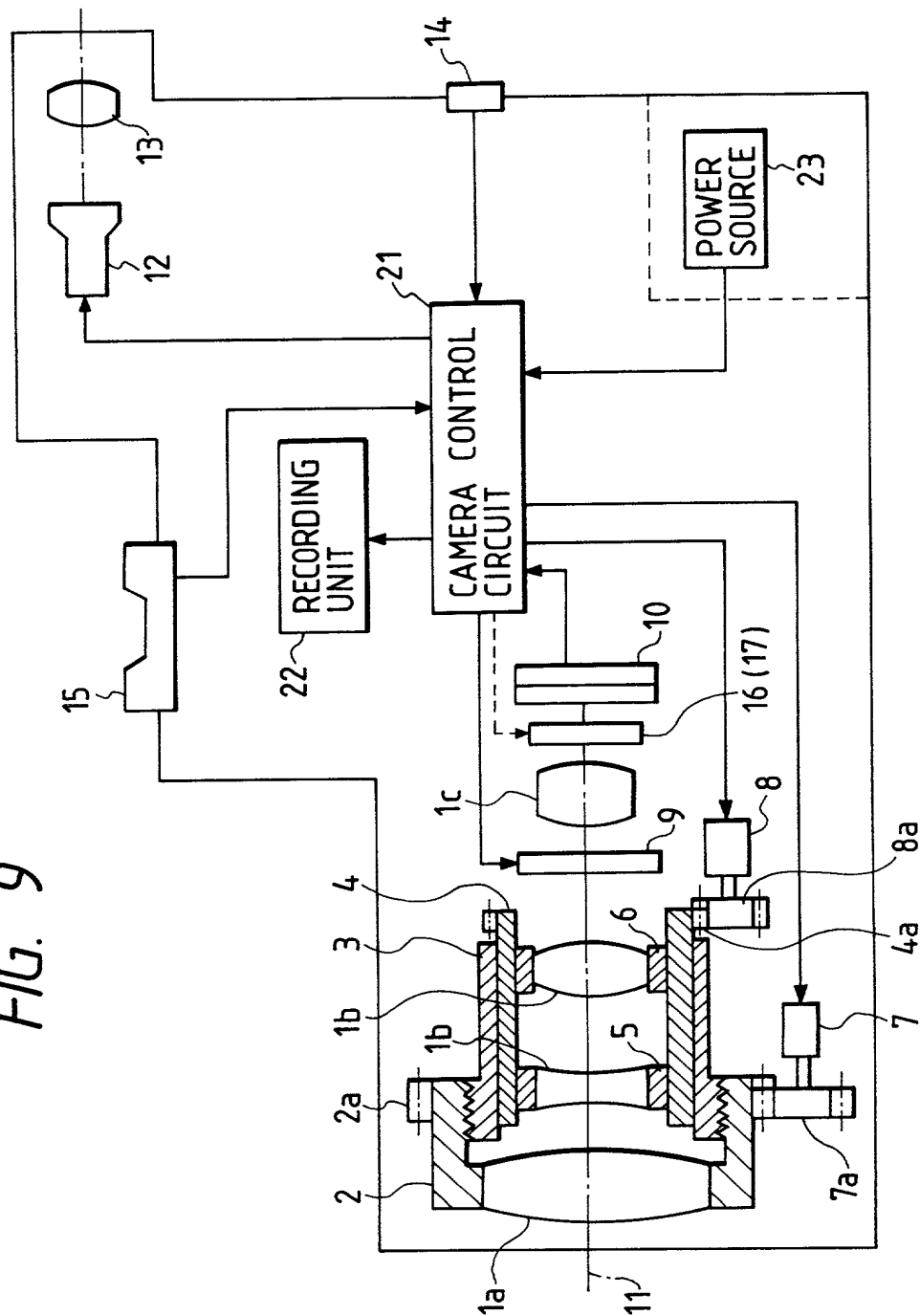


FIG. 9



O.G. FIG.	SUBCLASS
APPROVED BY	CLASS
DRAFTSMAN	

26240-ETH-1313

FIG. 8

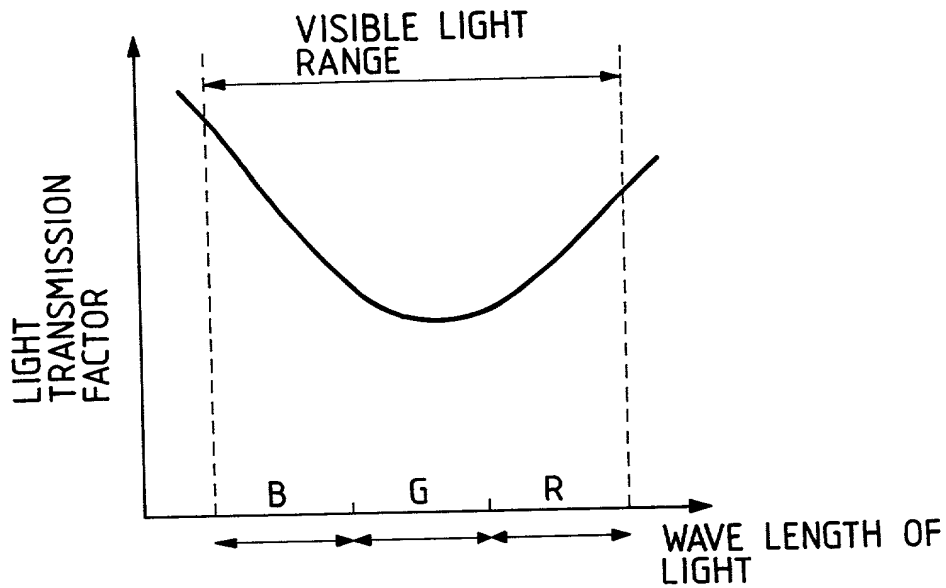
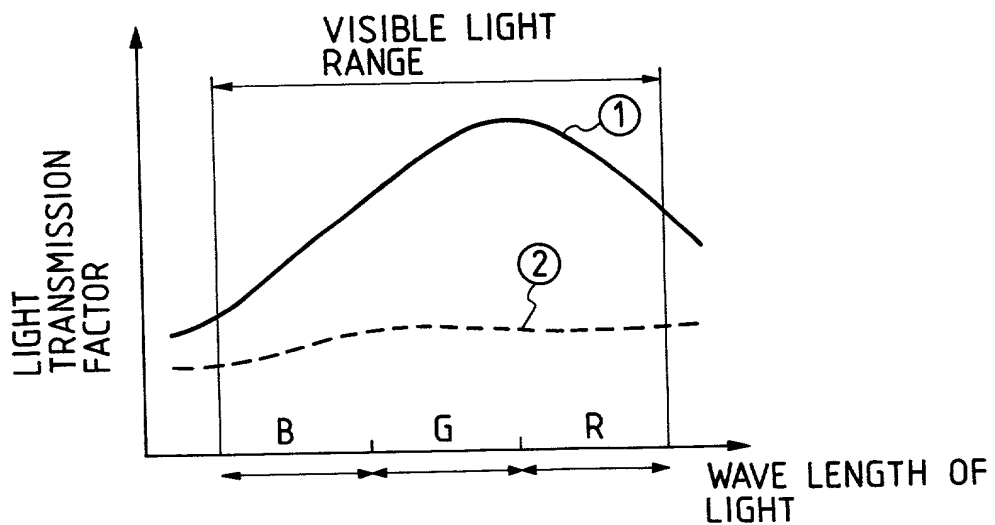


FIG. 10

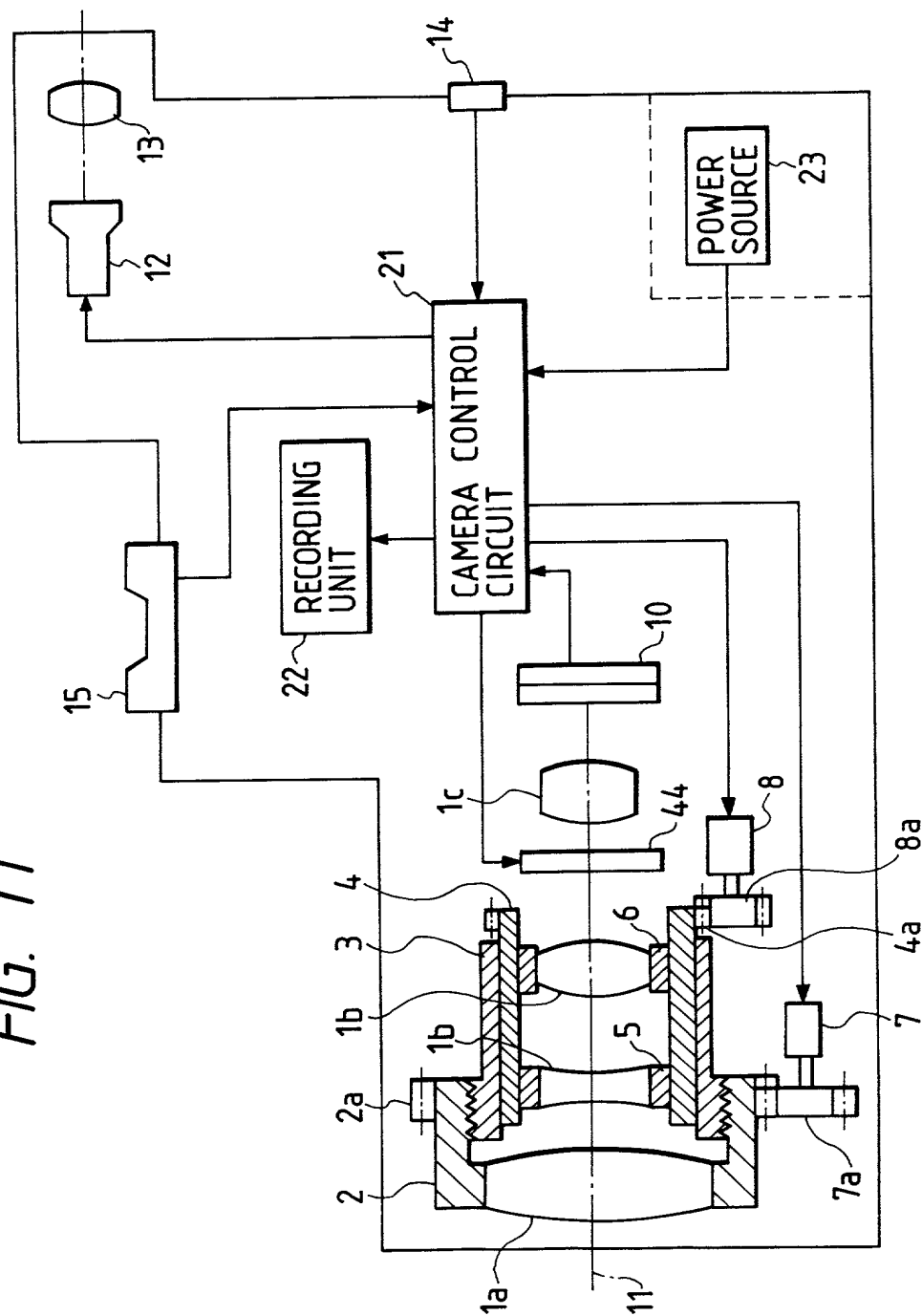




APPROVED	0.6 FIG.
BY	CLASS
DRAFTSMAN	SUNGLASS

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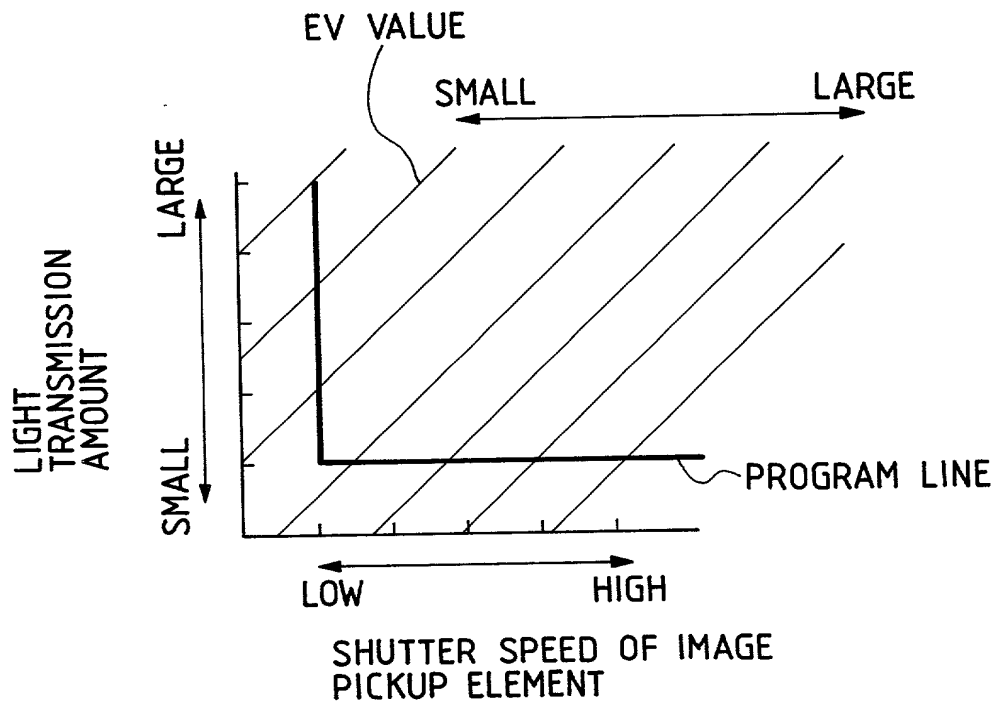
FIG. 11





APPROVED BY DRAFTSMAN	O.G. FIG.	
	CLASS	SUBCLASS

FIG. 13



0.0. FIG.	SUBCLASS
APPROVED BY	DRAFTSMAN

Approved by

FIG. 14A

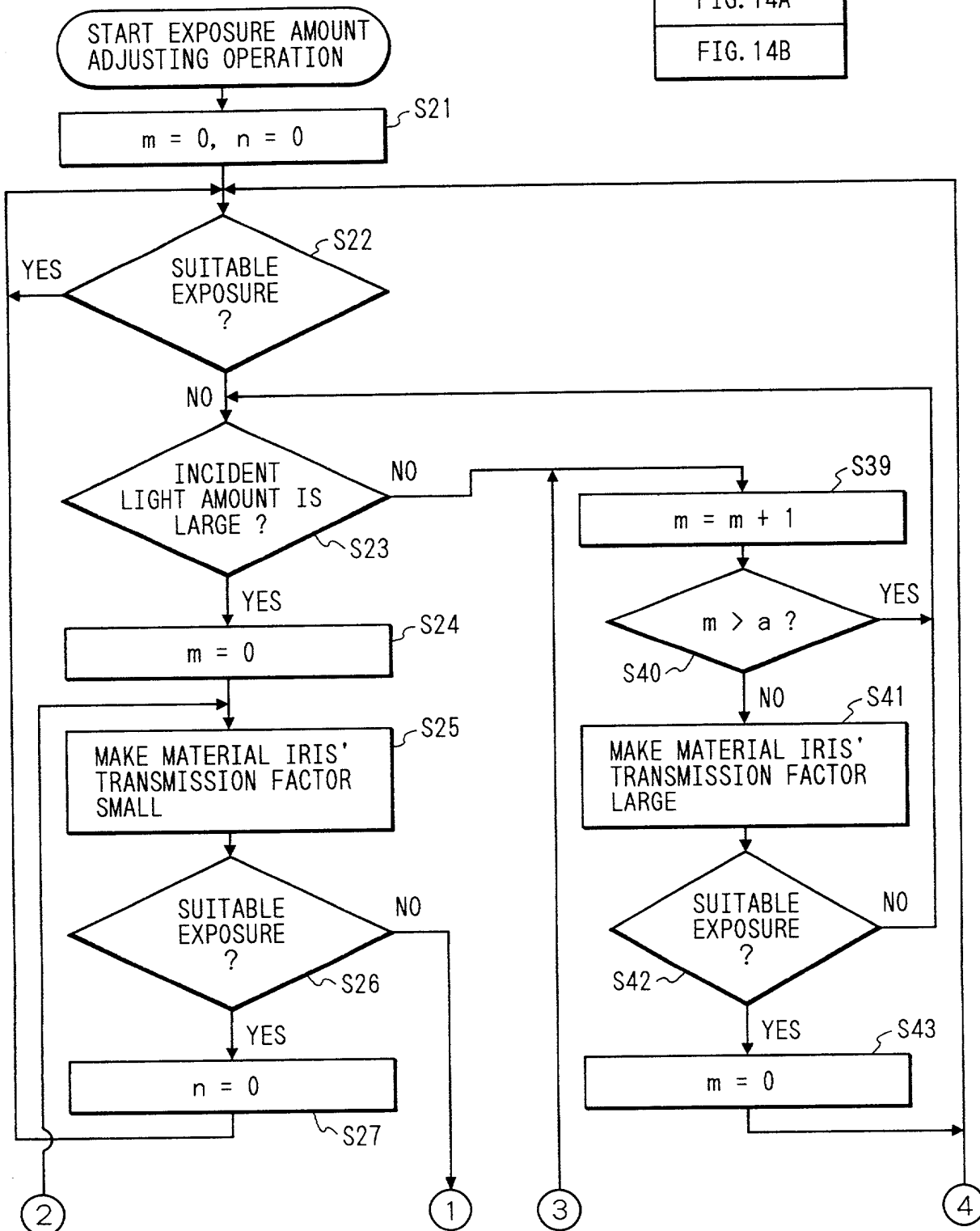
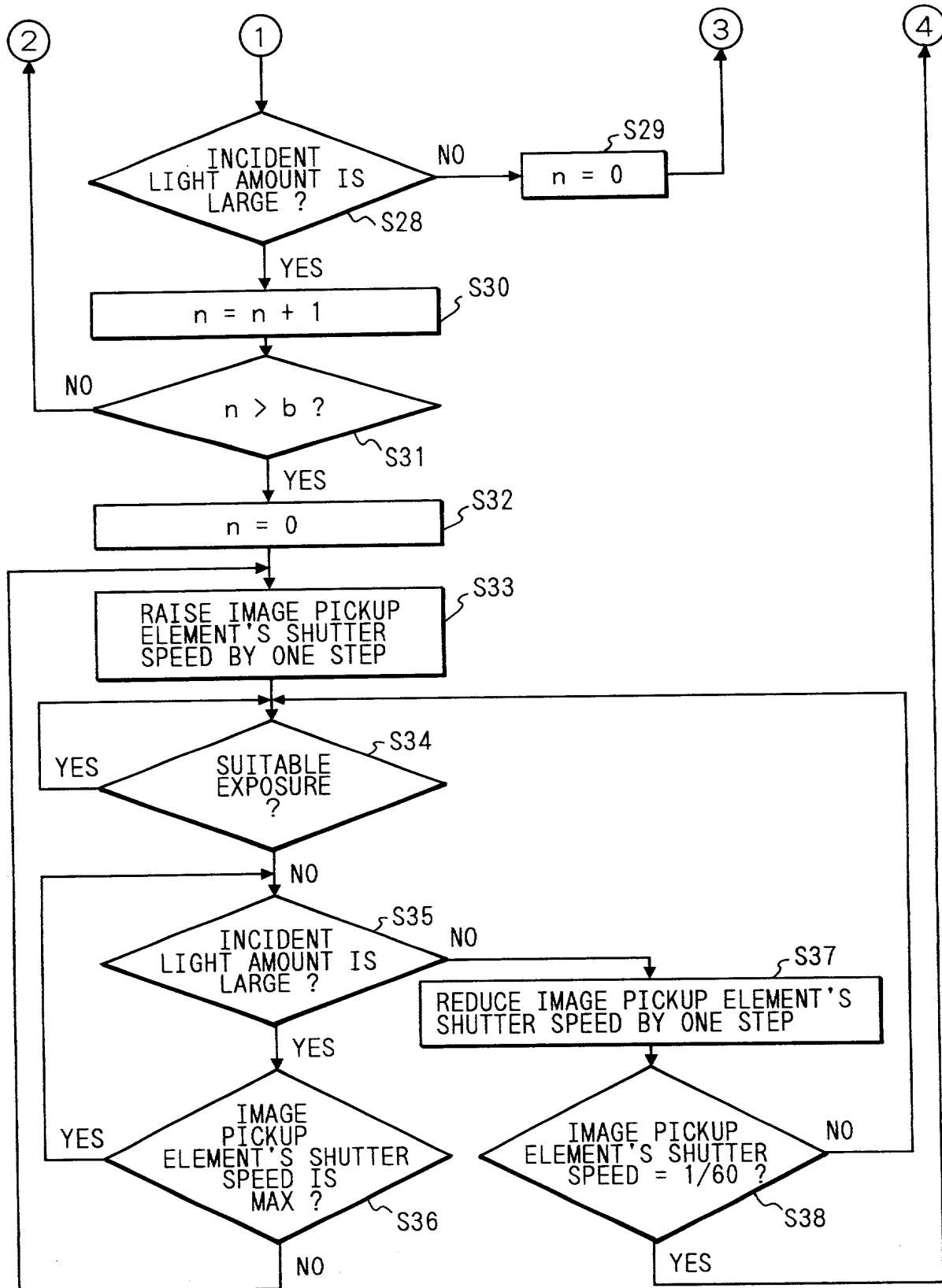


FIG. 14

FIG. 14A

FIG. 14B

# FIG. 14B

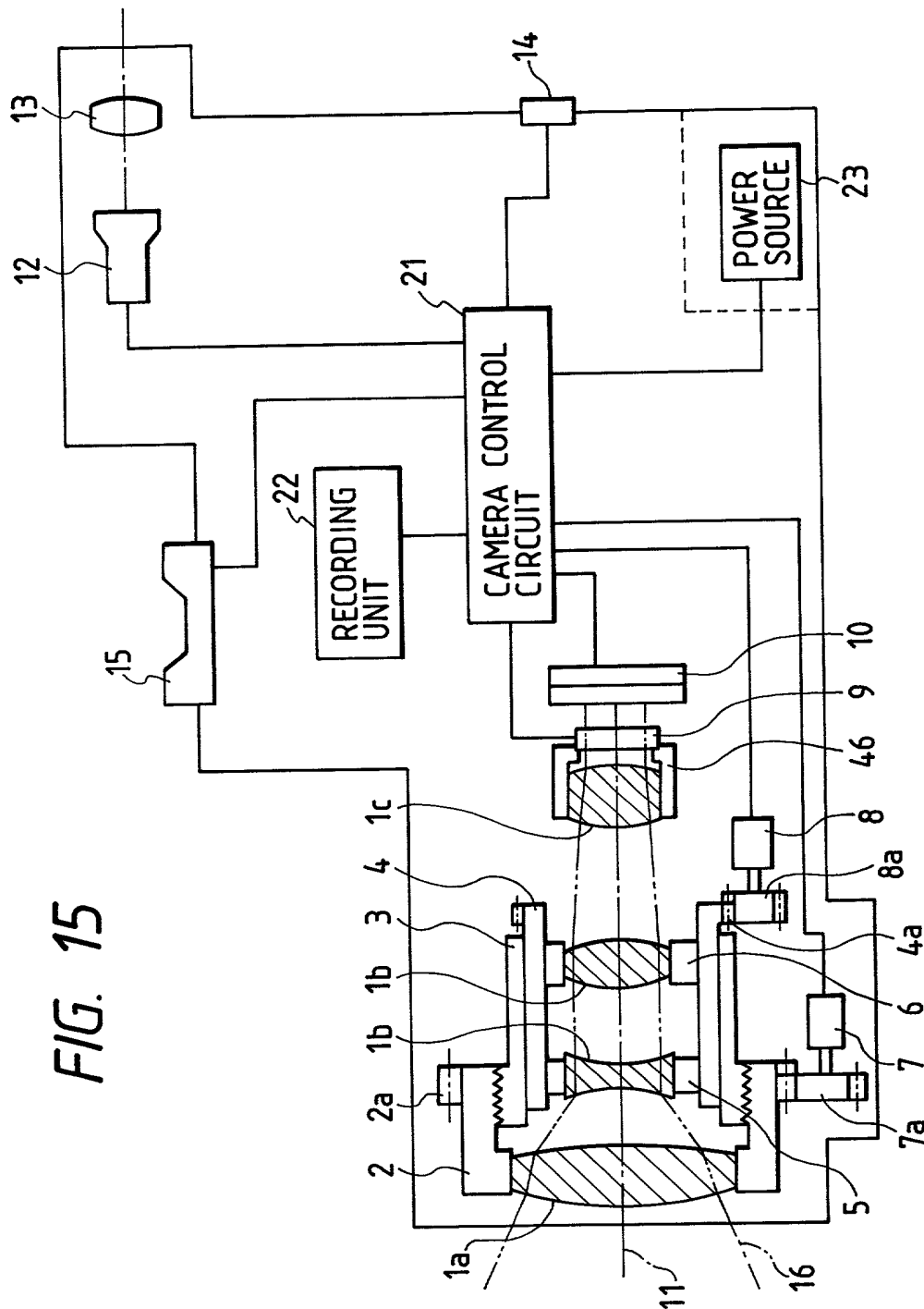


O.C. FIG.	SUBCLASS
APPROVED BY	CLASS
	DRAFTSMAN

SECRET

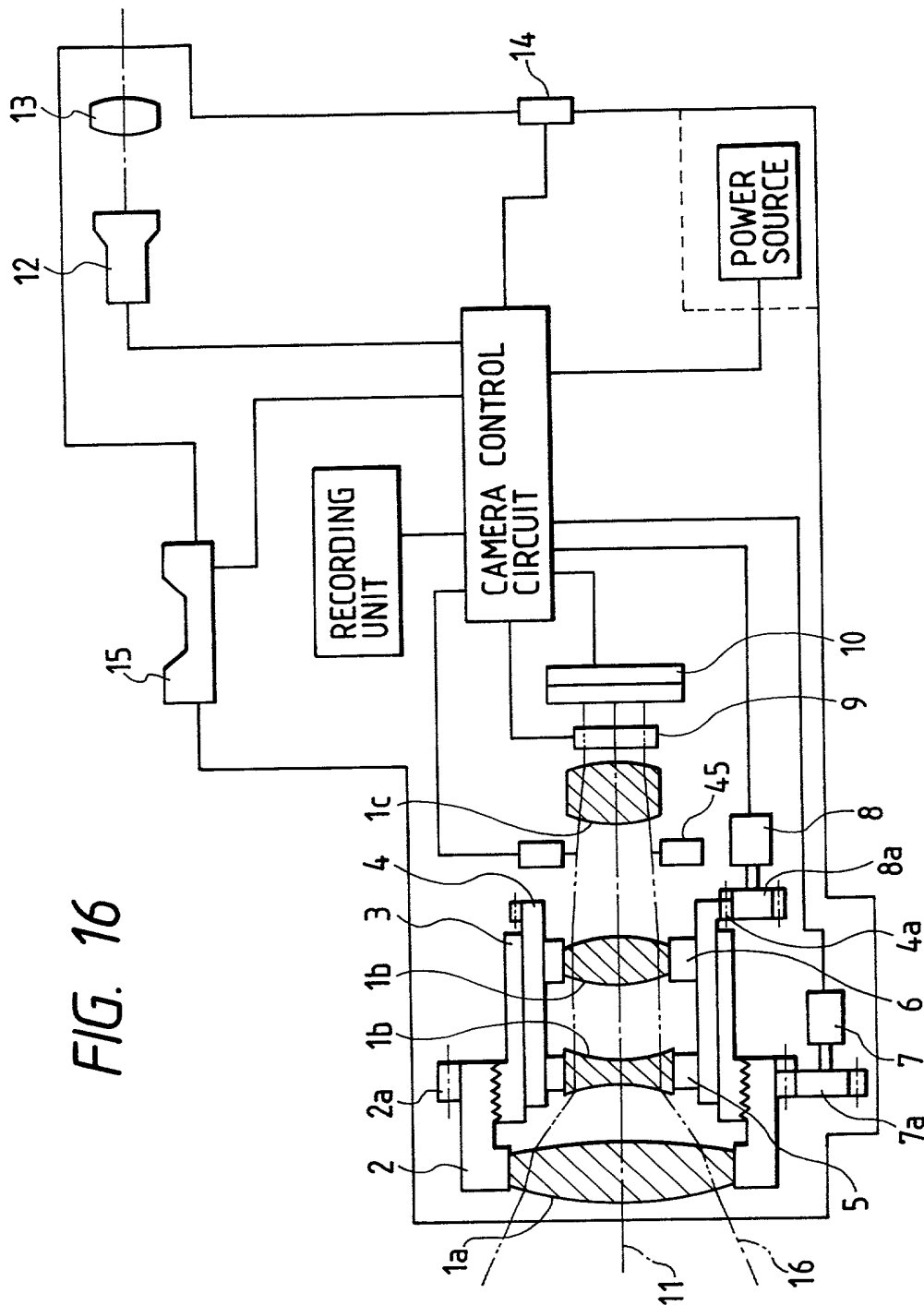
APPROVED	O.G. FIG.
BY	CLASS
DRAFTSMAN	SUBCLASS

FIG. 15



APPROVED	0.6. FIG.
BY	CLASS
DRAFTSMAN	SUBCLASS

FIG. 16



APPROVED  
BY  
DRAFTSMAN

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FIG. 17

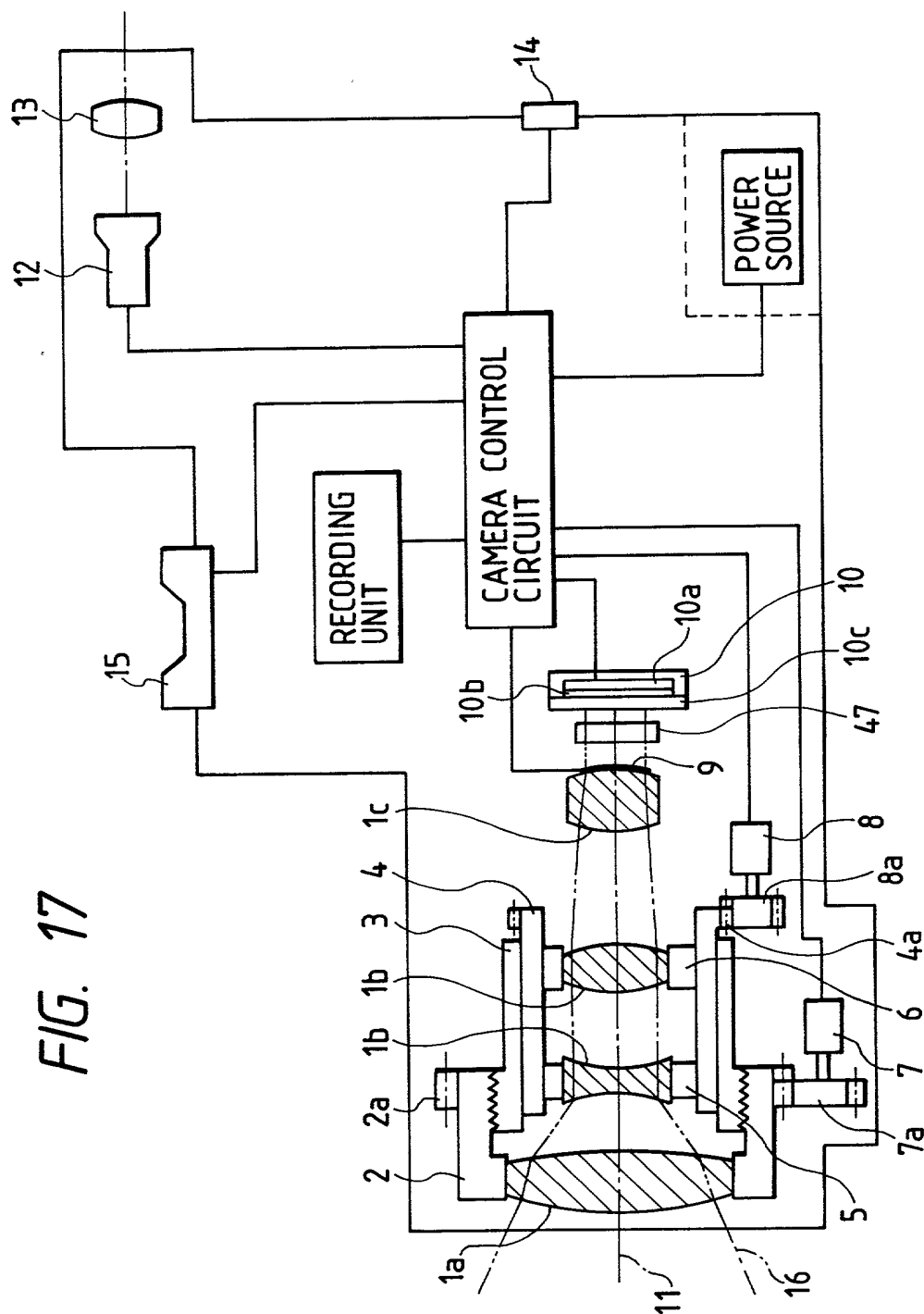




FIG. 18

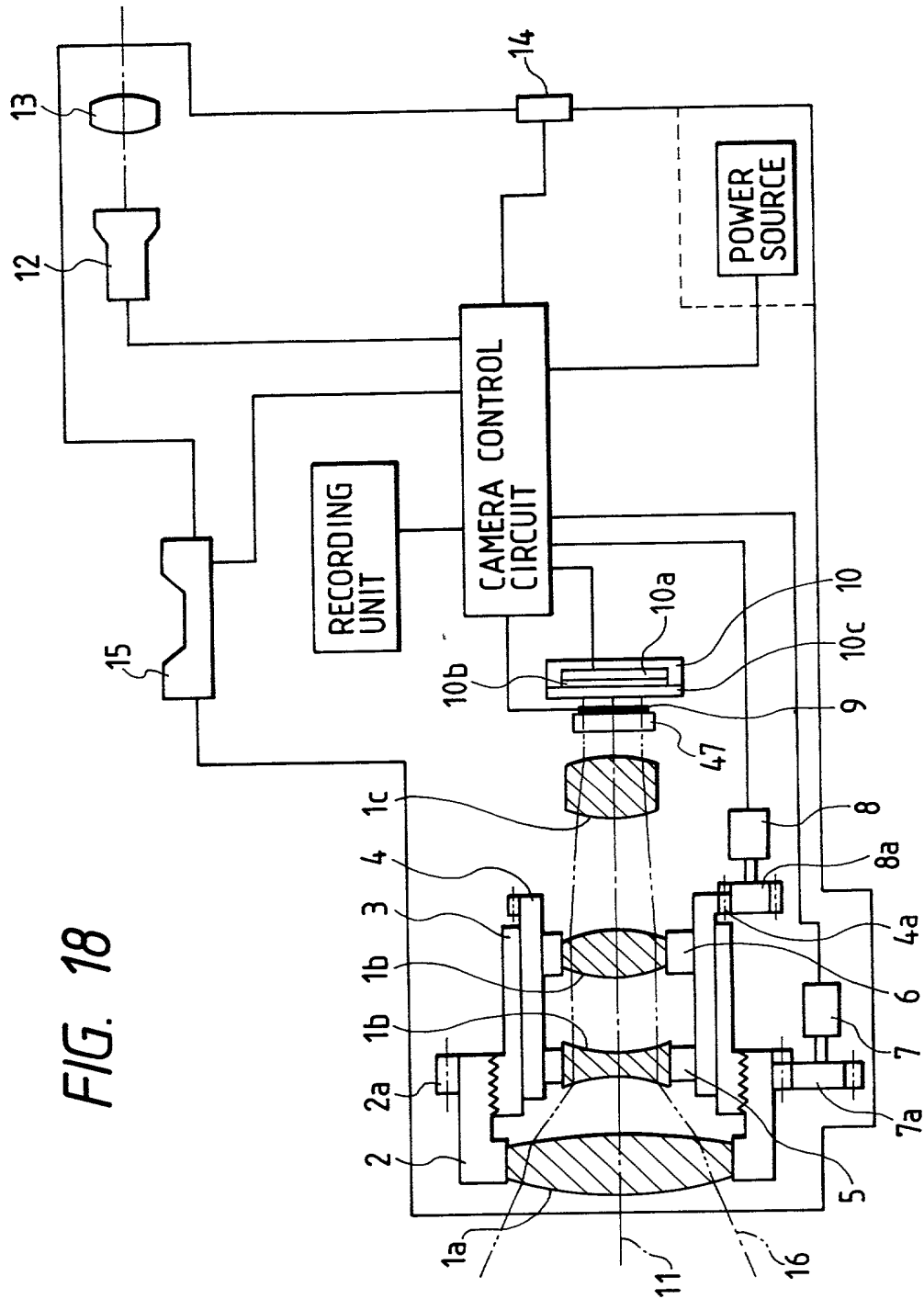
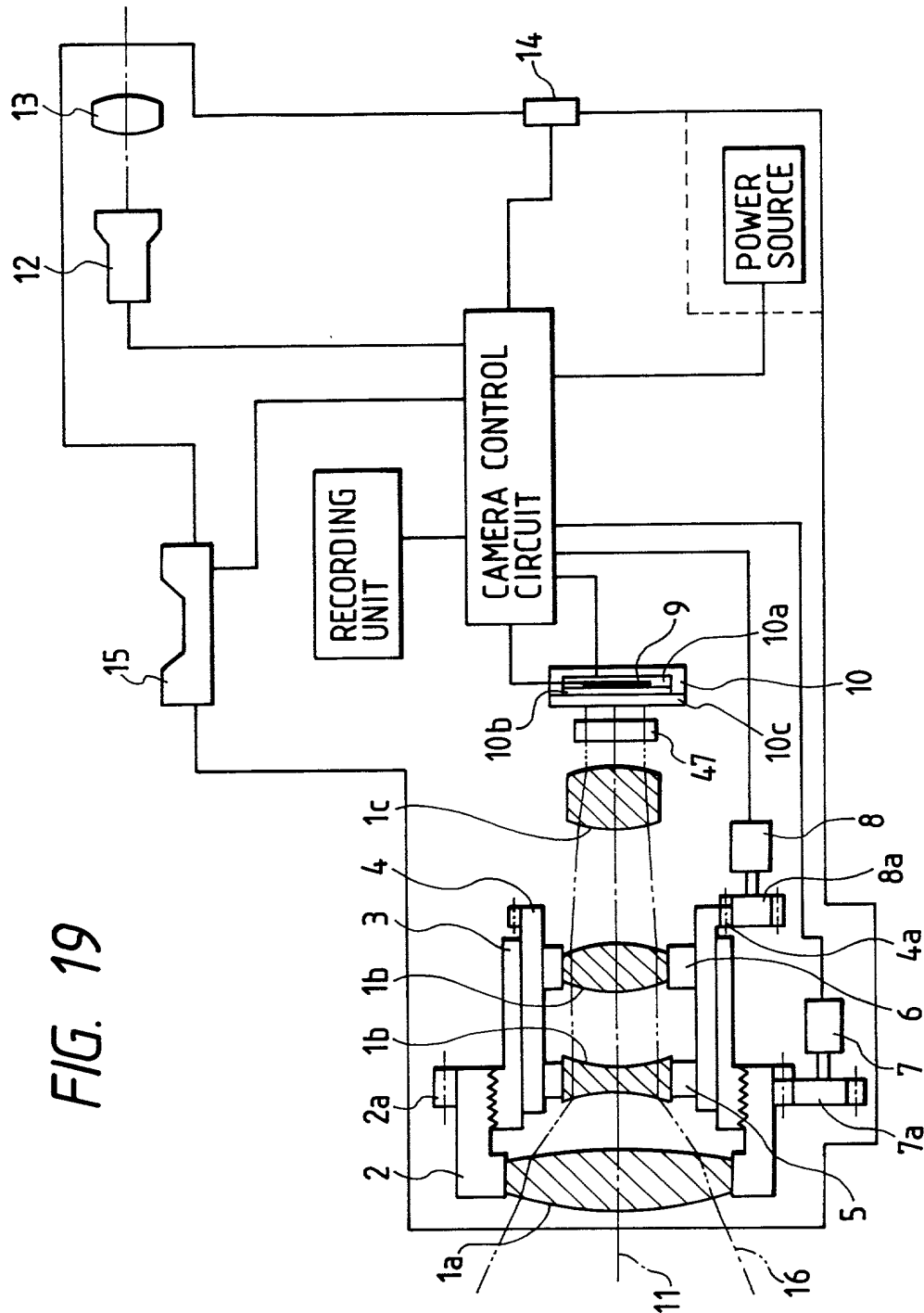


FIG. 19



APPROVED	0.6. FIG.
BY	CLASS
DRAFTSMAN	SUBCLASS

RECEIVED

FIG. 20

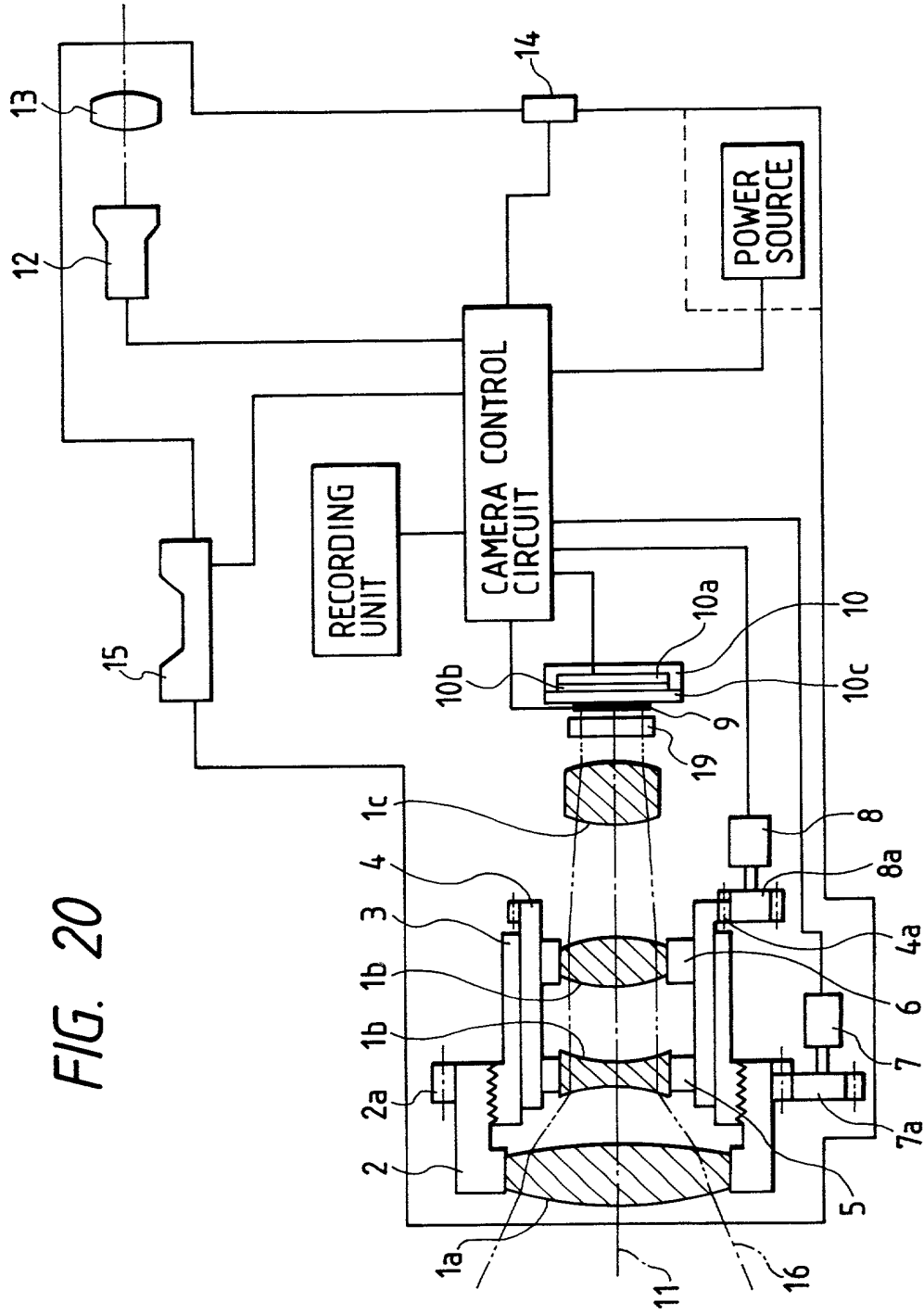
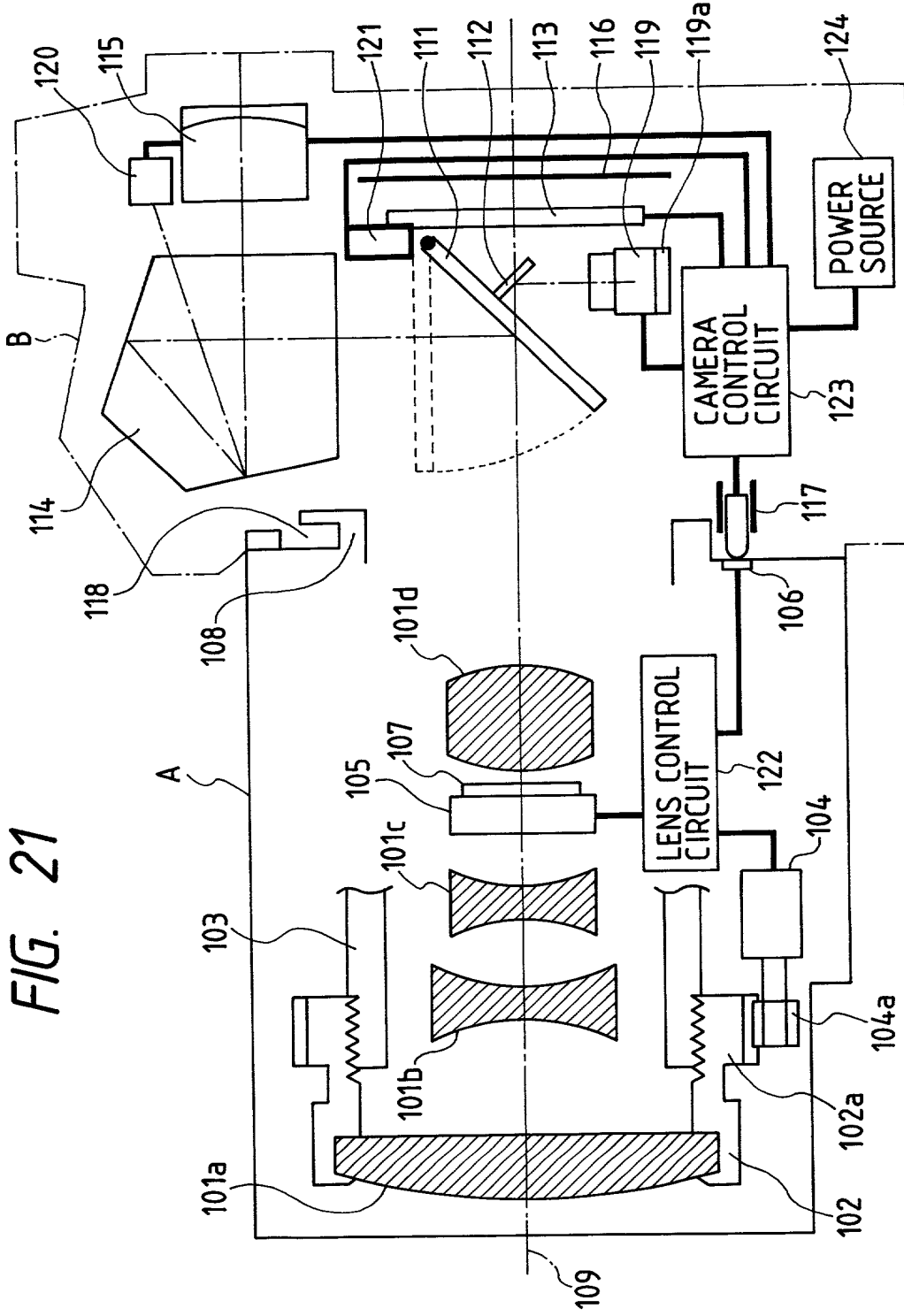
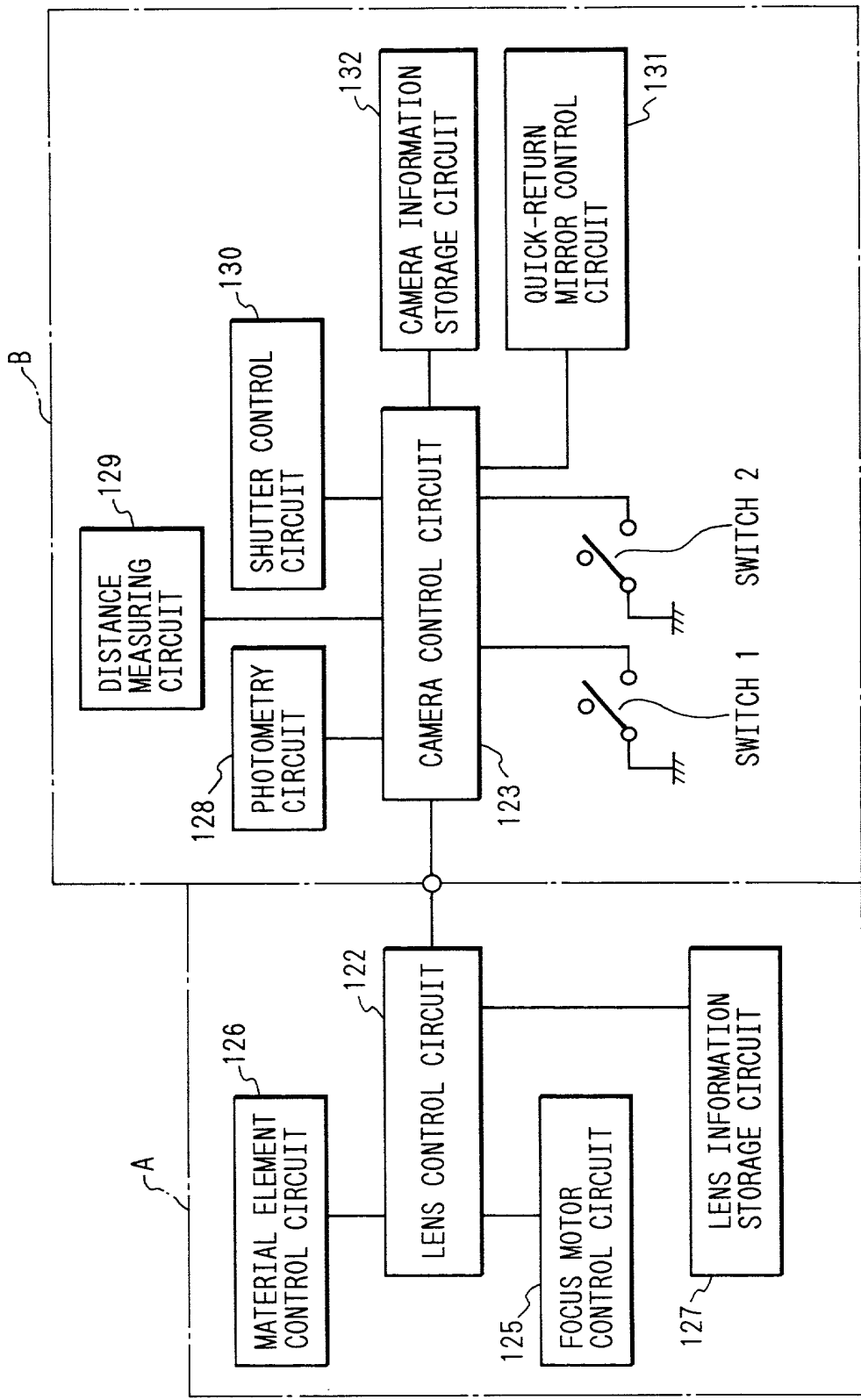


FIG. 21



APPROVED	O. G. FIG.
BY	CLASS
DRAFTSMAN	SUBCLASS

FIG. 22



APPROVED	0.0 FIG.
BY	SUBCLASS
CRAFTSMAN	CLASS

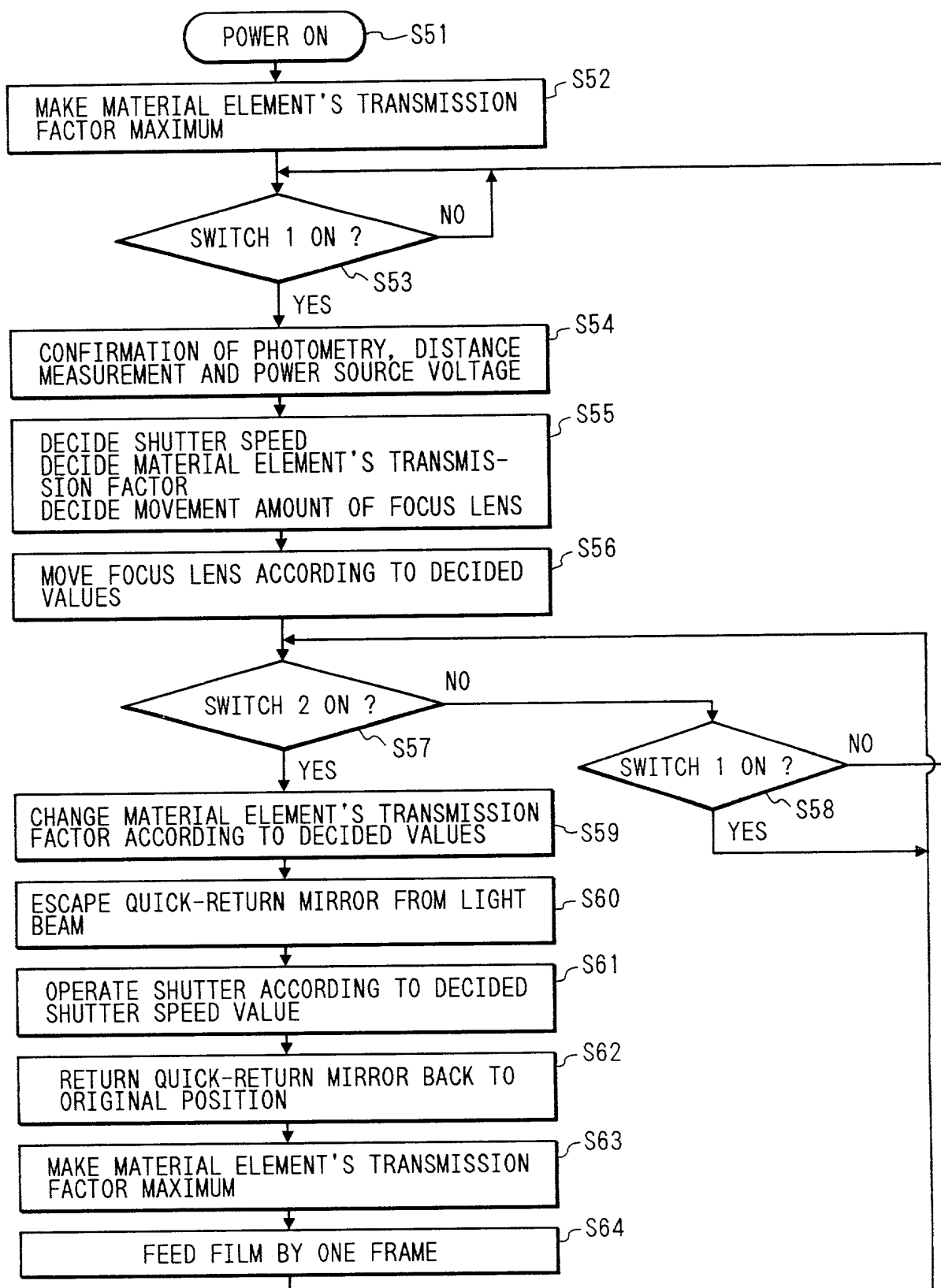
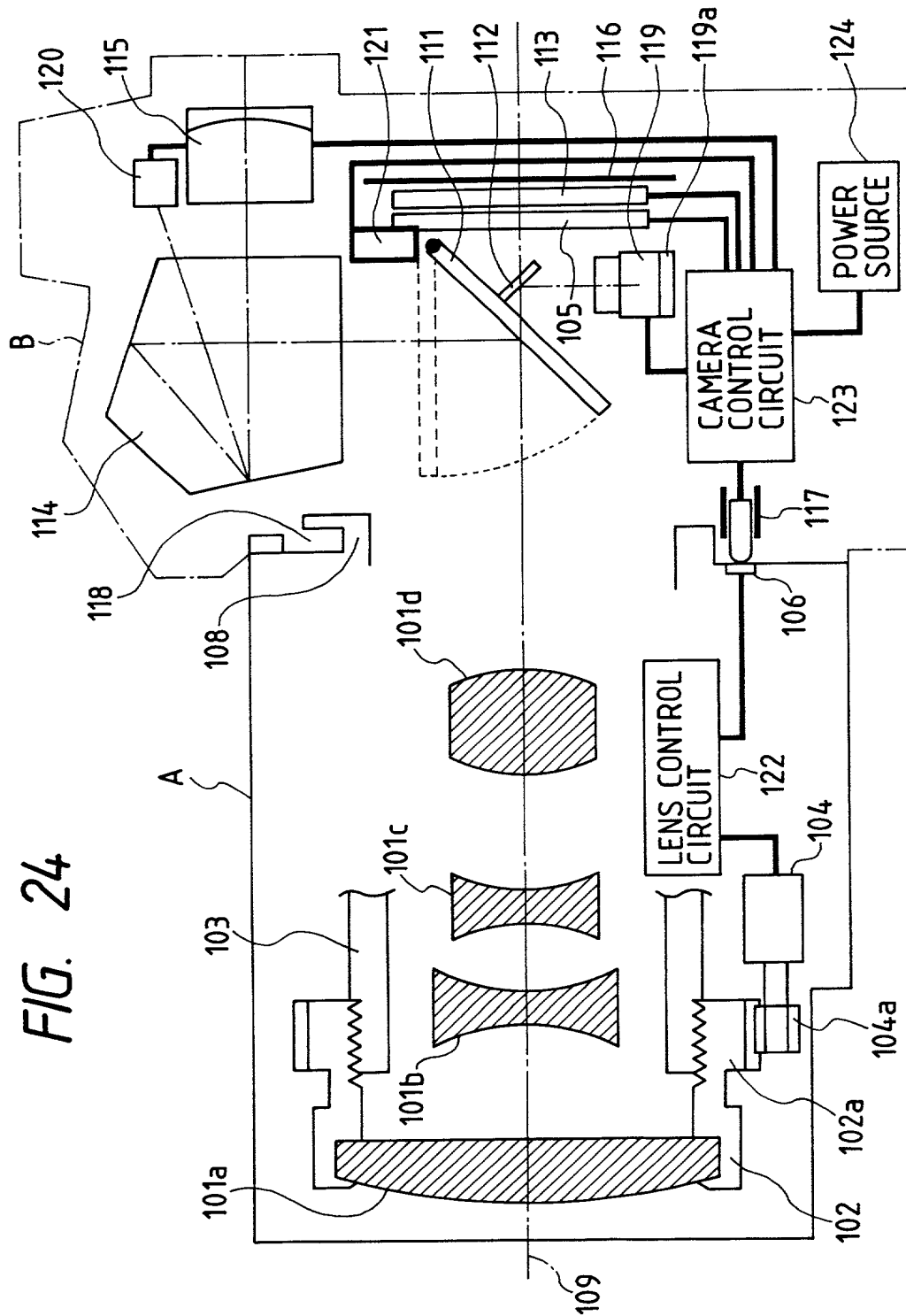


FIG. 24



APPROVED	BY	CLASS	SUBCLASS
	DRAFTSMAN		

O.G. FIG.





APPROVED	0. C. FIG.
BY	CLASS
DRAFTSMAN	SUBCLASS

4666443-47231313

FIG. 26

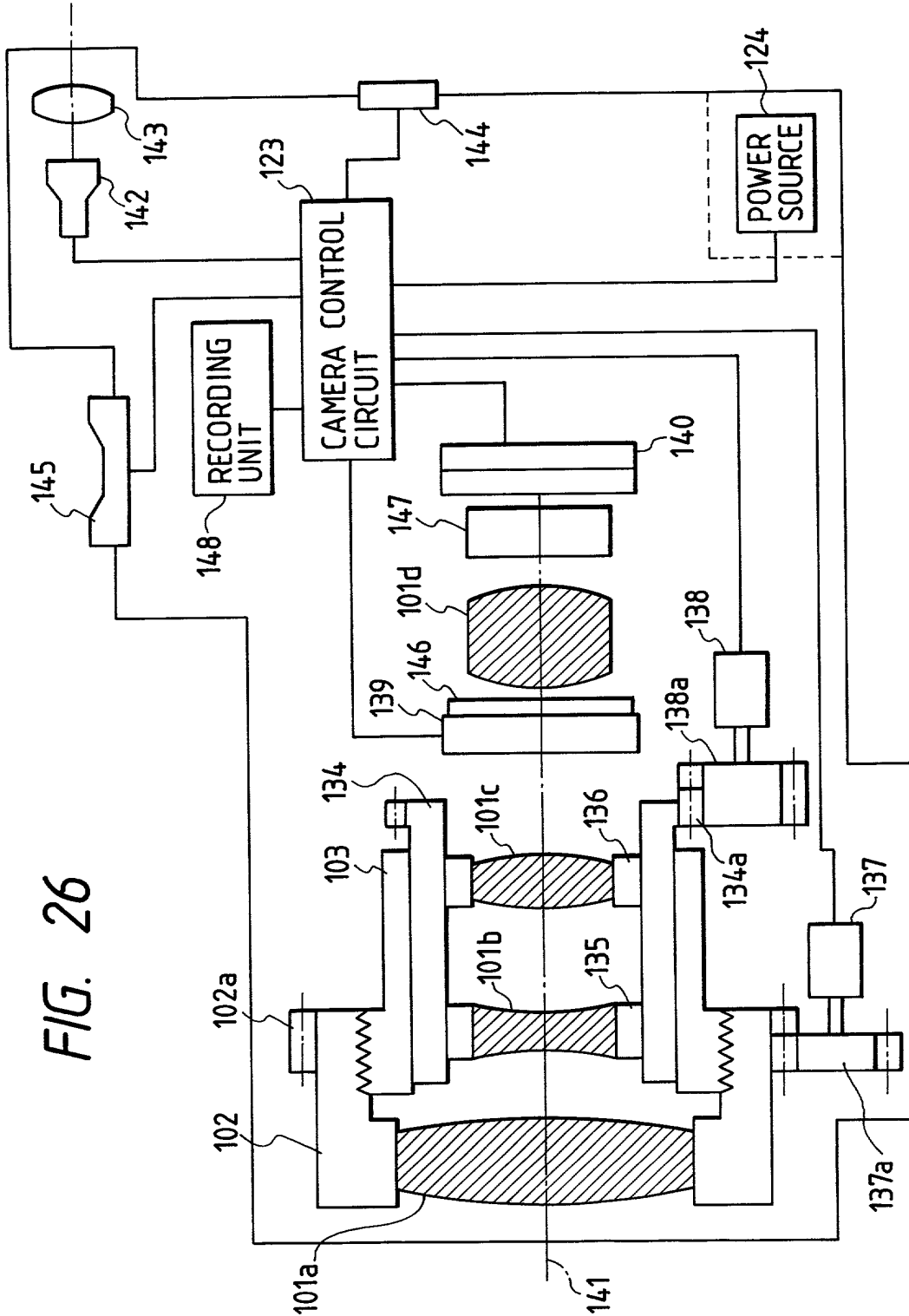
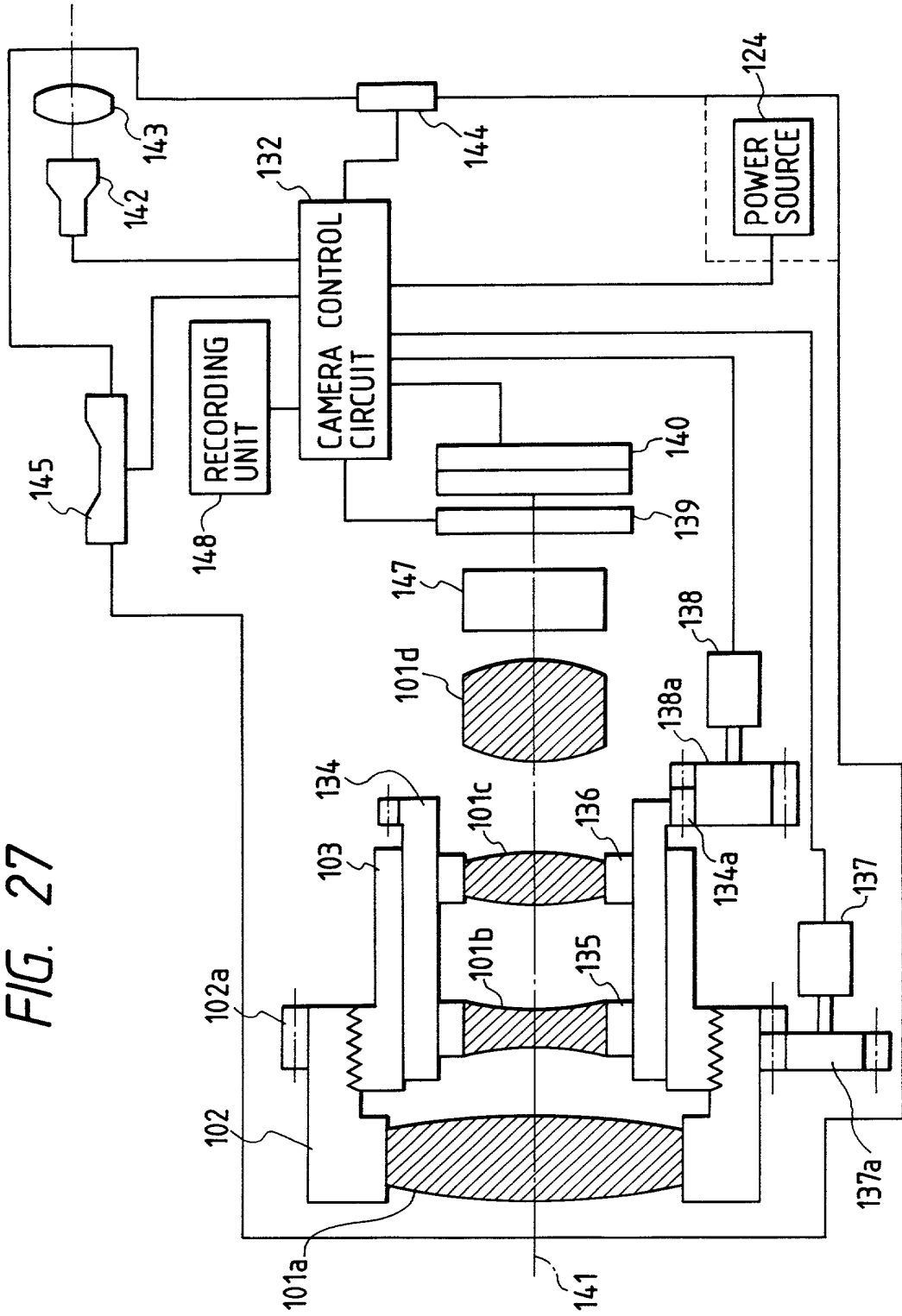


FIG. 27



APPROVED	0.6. FIG.
BY	CLASS
DRAFTSMAN	SUBCLASS

466440 "Electronics"

FIG. 28

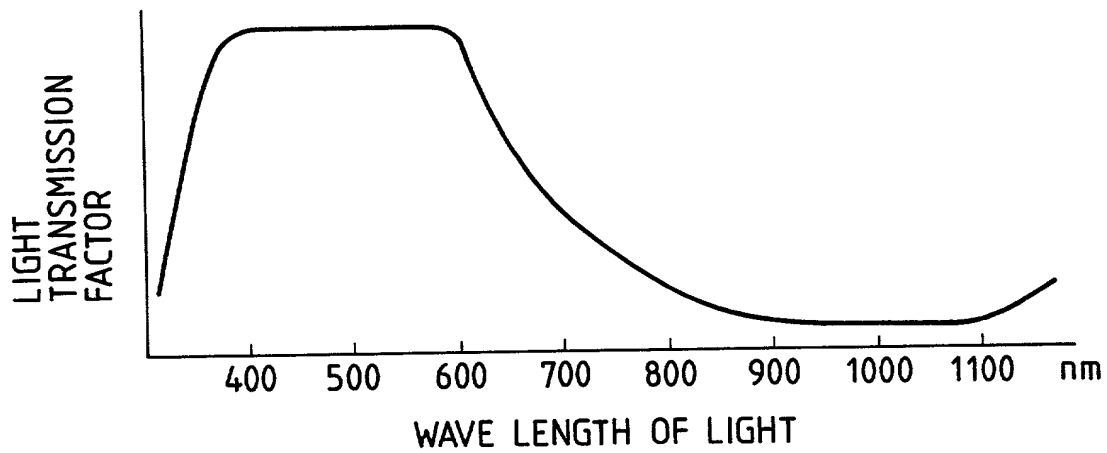


FIG. 29

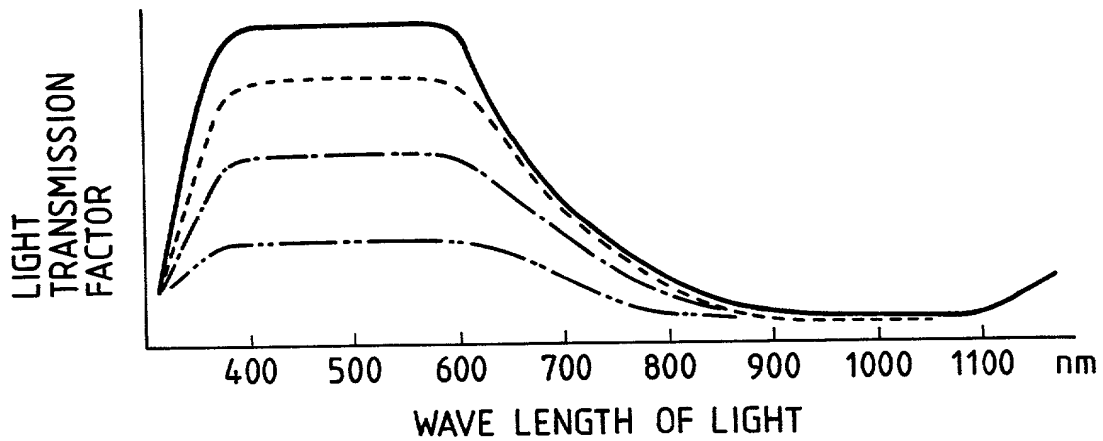
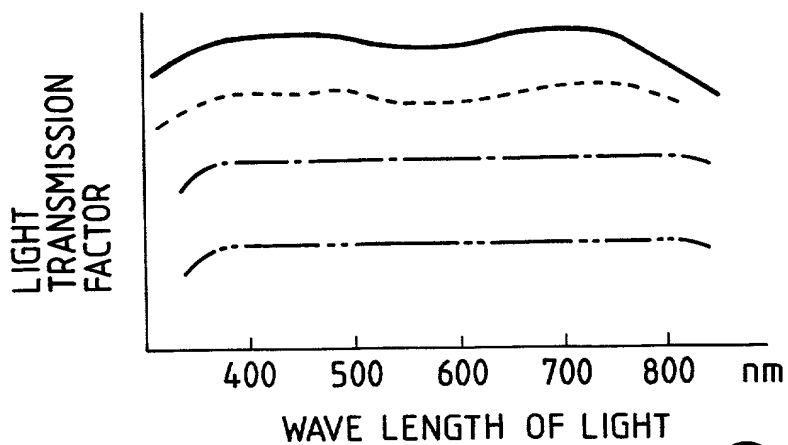


FIG. 30



APPROVED	BY	CLASS	SUBCLASS
		DRAFTSMAN	

FIG. 31

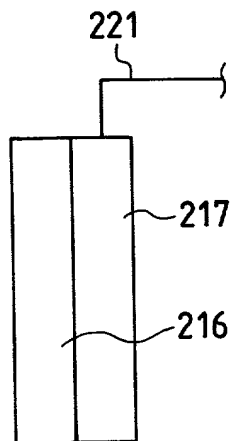


FIG. 32

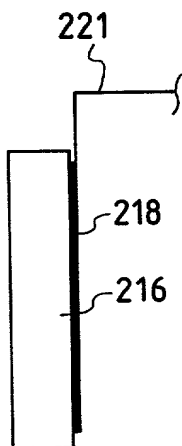


FIG. 33

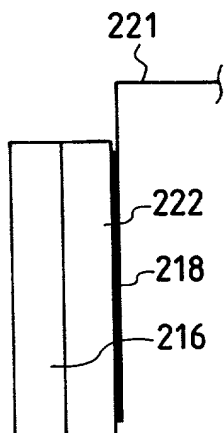


FIG. 34

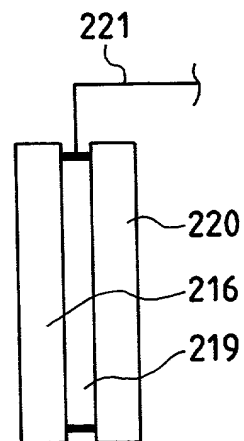
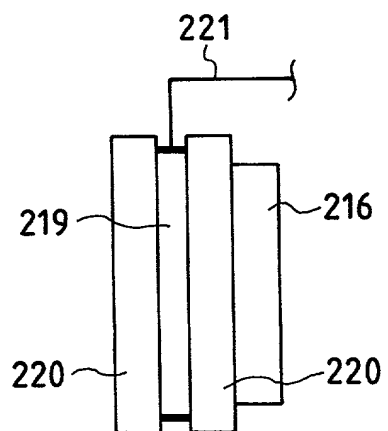


FIG. 35



Approved for Release



O. C. FIG.	SUBCLASS
APPROVED BY	CLASS
DRAFTSMAN	

FIG. 37

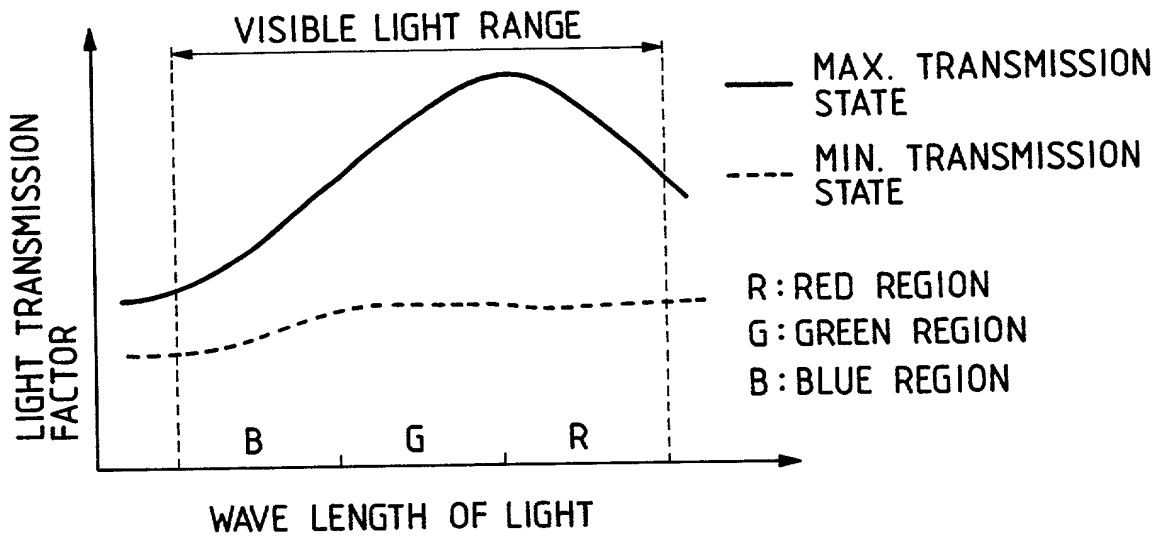
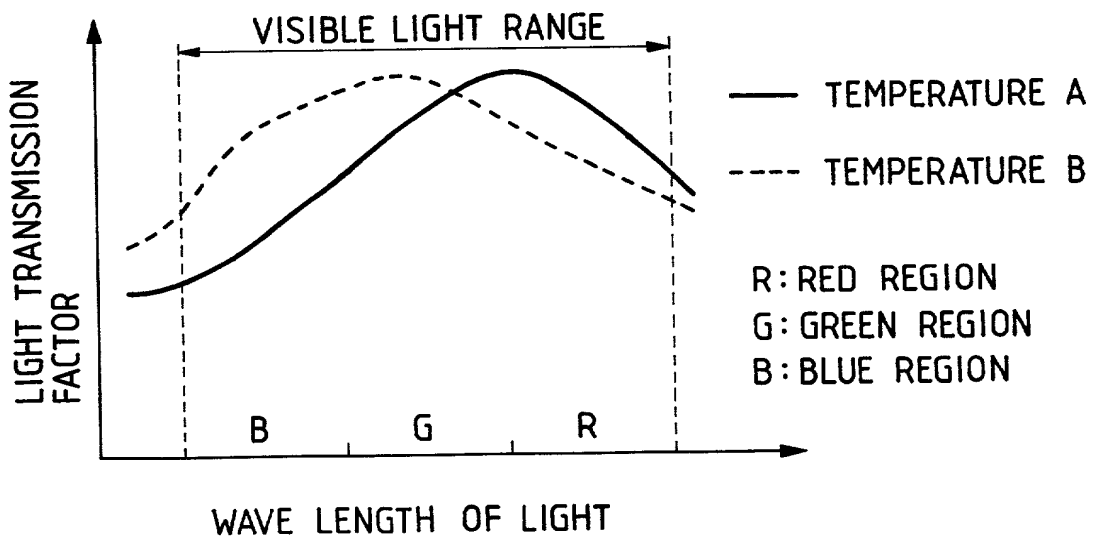


FIG. 38



[illegible]

APPROVED	O. G. FIG.
BY	CLASS
DRAFTSMAN	SUBCLASS

FIG. 40

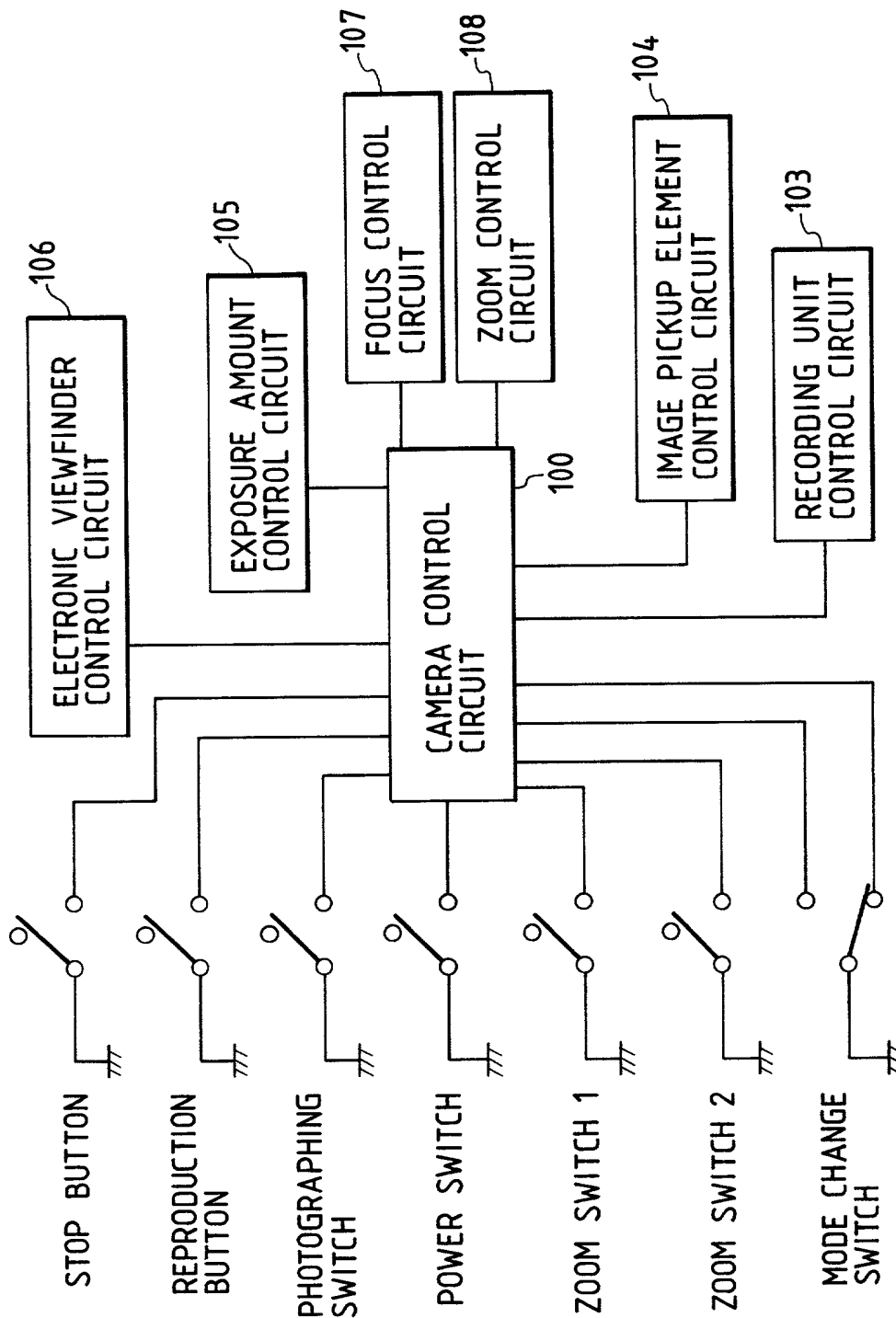




FIG. 41A

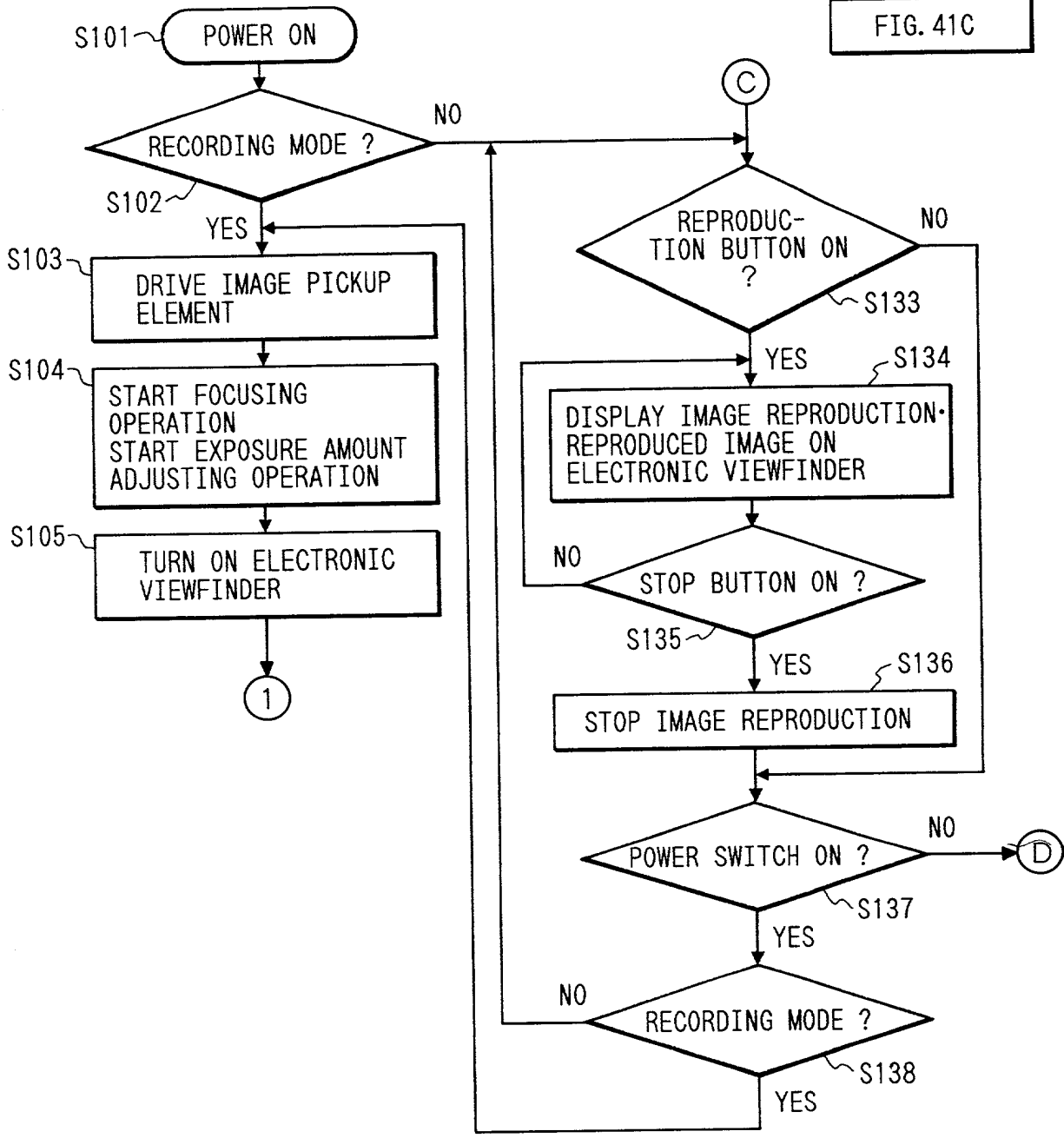


FIG. 41

FIG. 41A
FIG. 41B
FIG. 41C

FIG. 41B

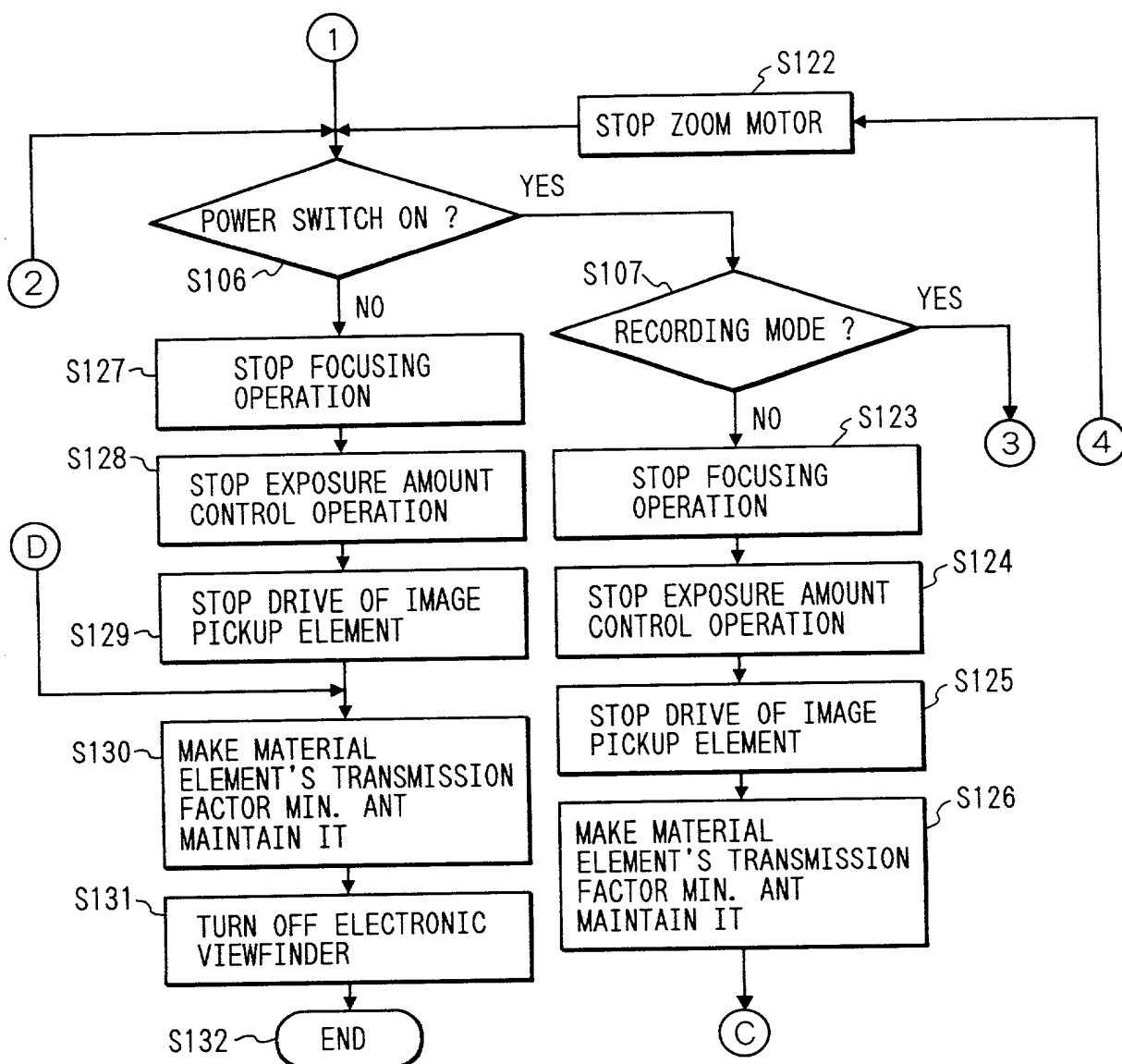
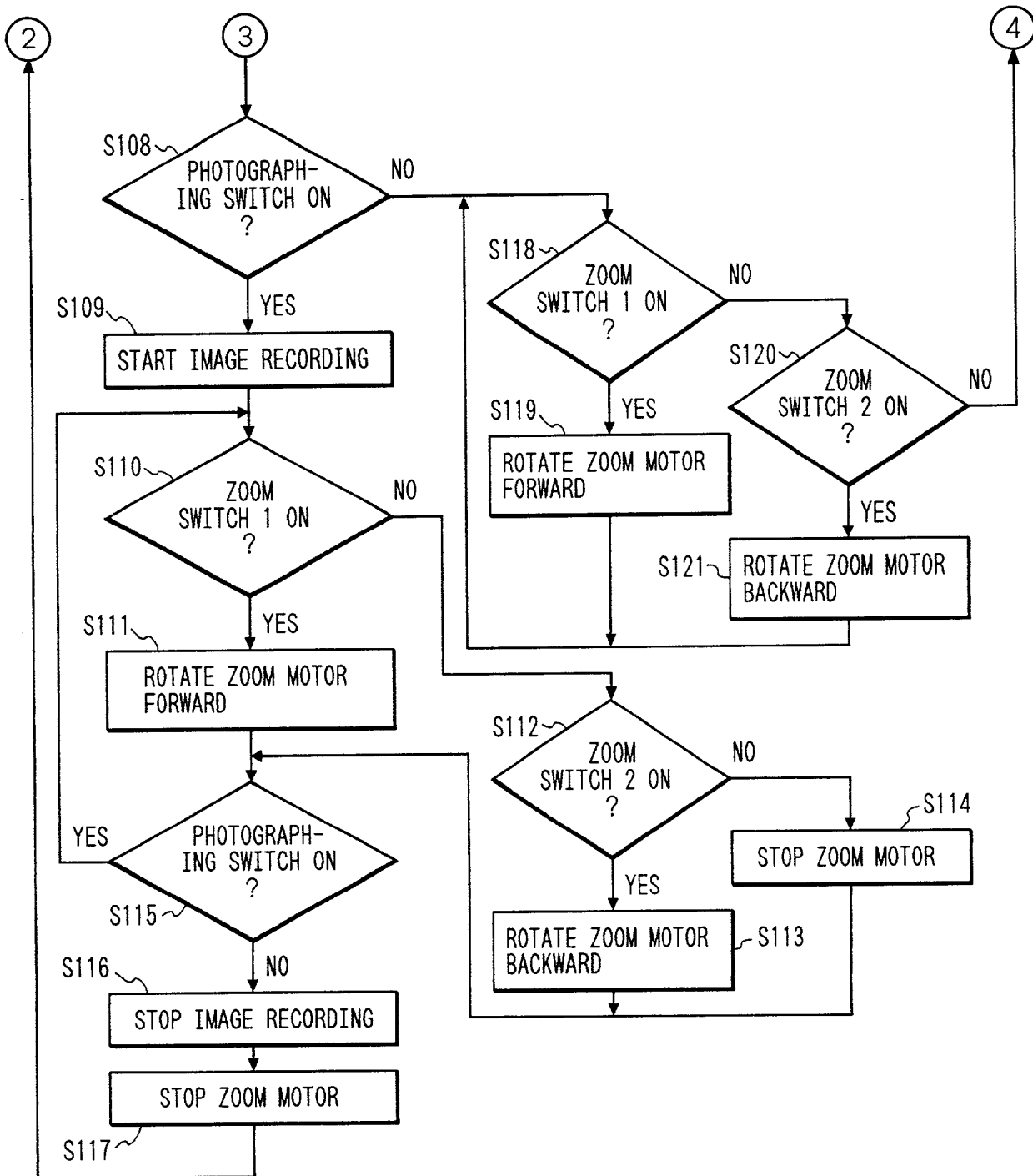


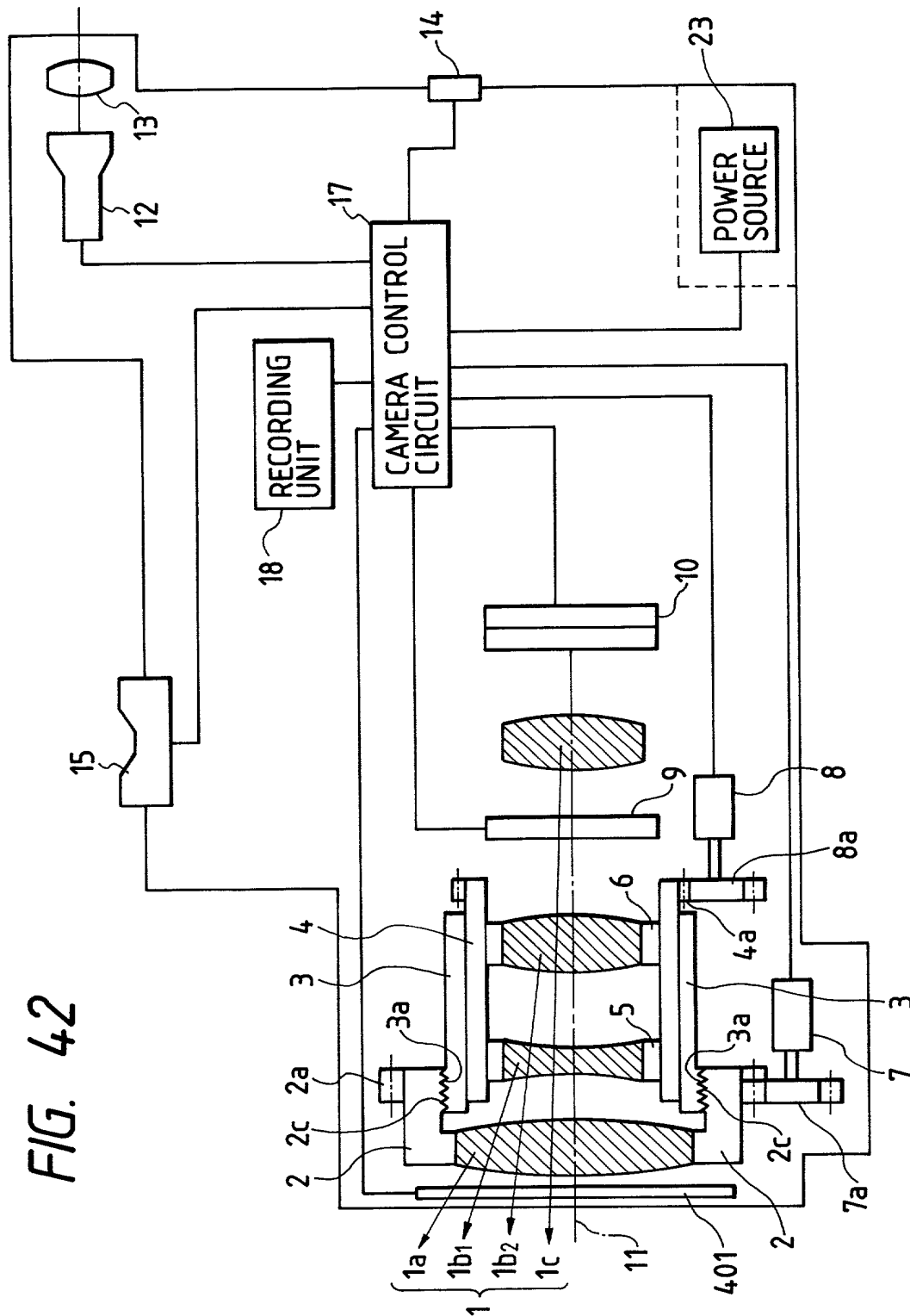
FIG. 41C



0.6 FIG.	SUBCLASS
APPROVED BY	DRAFTSMAN

"Echo" Enhanced

FIG. 42



O.G. FIG.	SUBCLASS
	CLASS
APPROVED	DRAFTSMAN
BY	

FIG. 43A

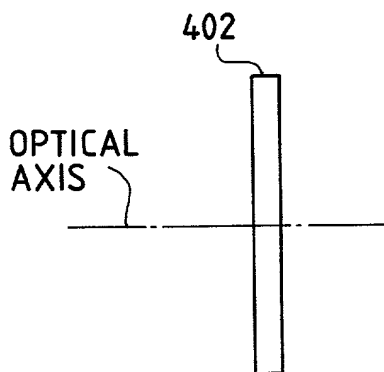


FIG. 43B

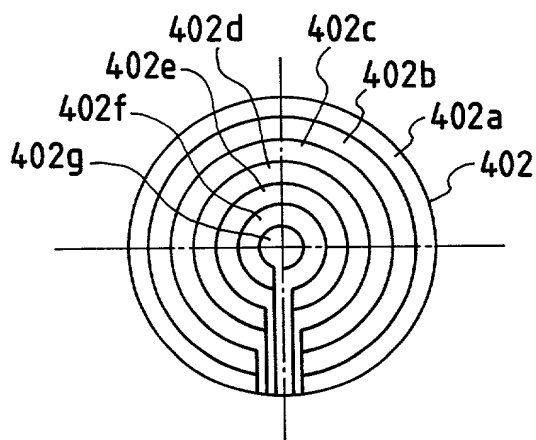


FIG. 45

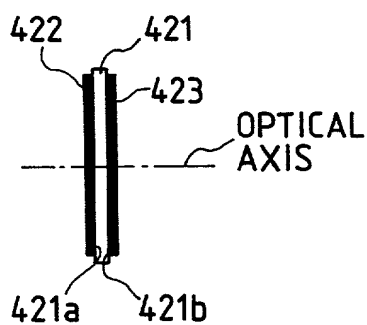


FIG. 46A

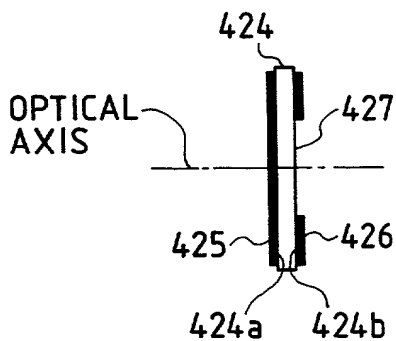
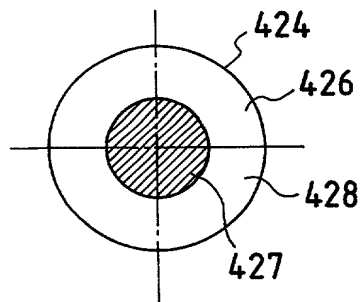


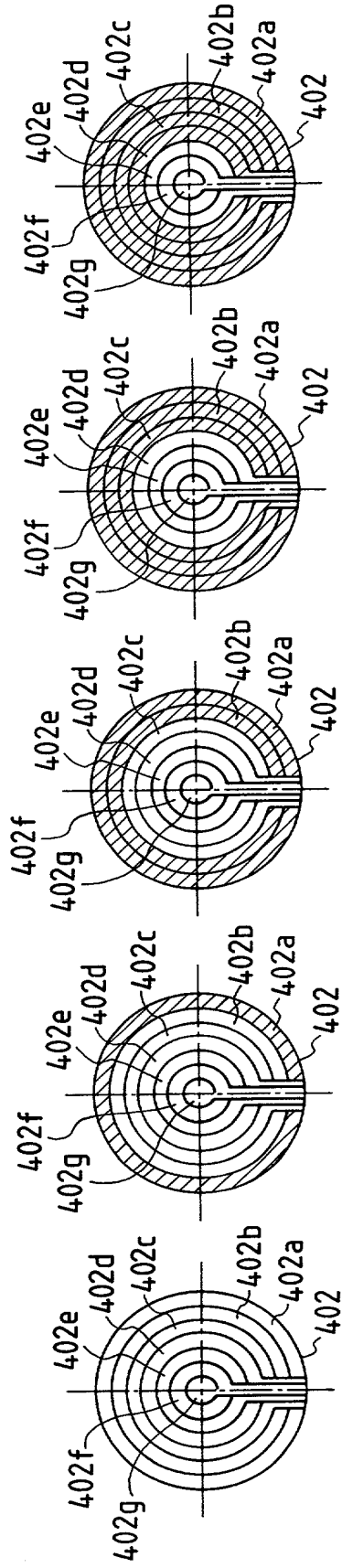
FIG. 46B



46000000 2-11-13-15-17

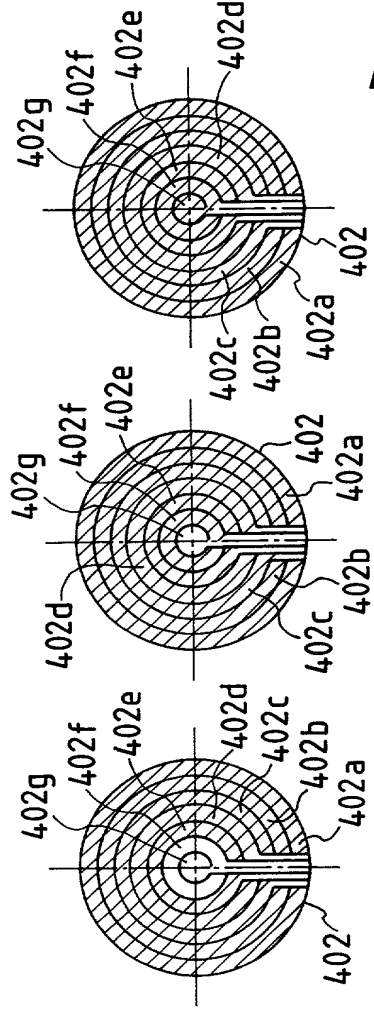
APPROVED BY	0.6 FIG.	
	CLASS	SUBCLASS
DRAFTSMAN		

FIG. 44A FIG. 44B FIG. 44C FIG. 44D FIG. 44E



LARGE TRANSMISSION FACTOR (DEPTH OF FIELD IS SHALLOW)

FIG. 44F FIG. 44G FIG. 44H



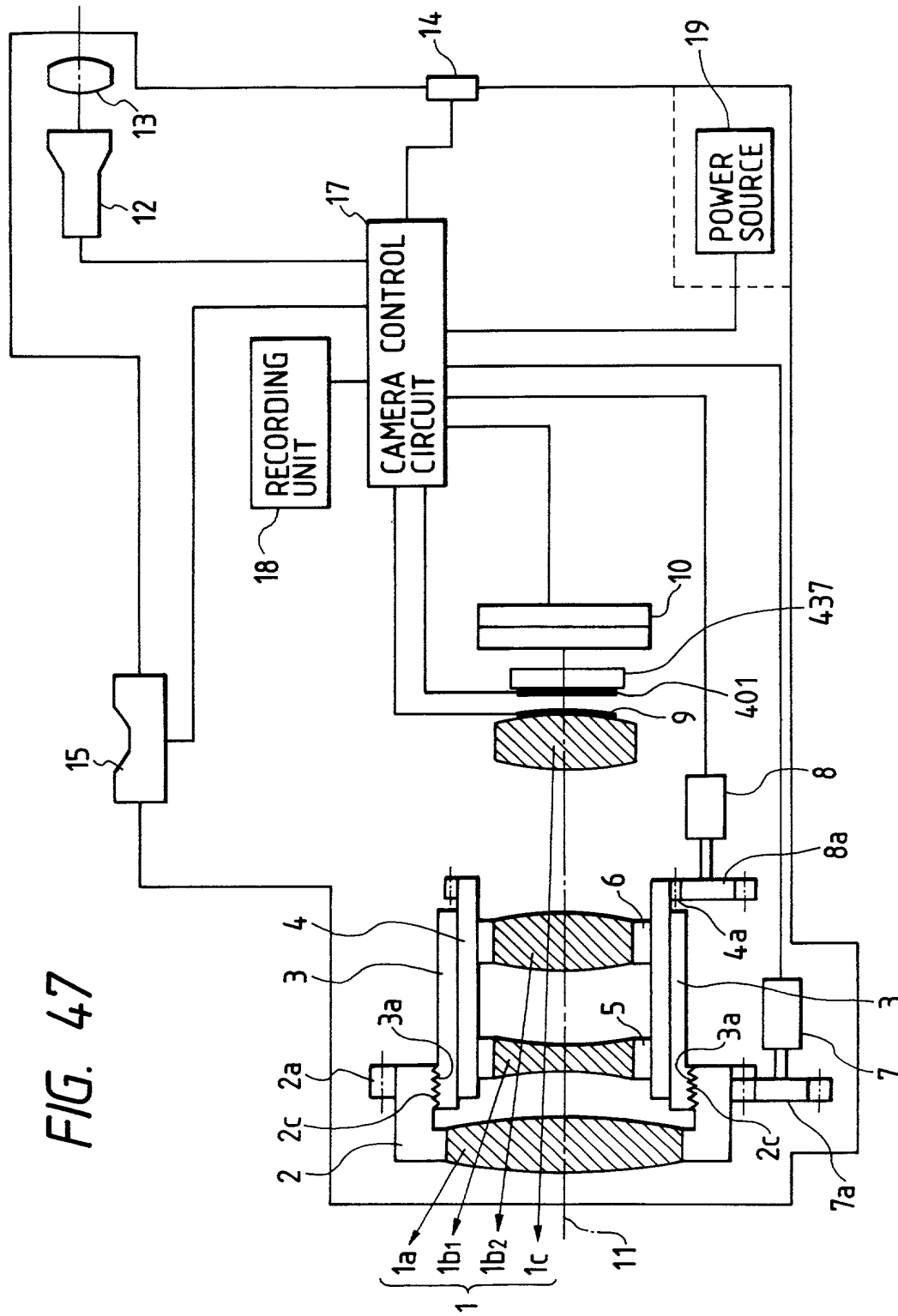
SMALL TRANSMISSION FACTOR  
(DEPTH OF FIELD IS DEEP)

AREA DENOTES AREA HAVING  
SMALL TRANSMISSION FACTOR

APPROVED	BY	CLASS	SUBCLASS
	DRAFTSMAN		

0.6. FIG. 47

FIG. 47



APPROVED	0.6 FIG.
BY	CLASS
DRAFTSMAN	SUBCLASS

RECEIVED "ELECTRONICS"

FIG. 48

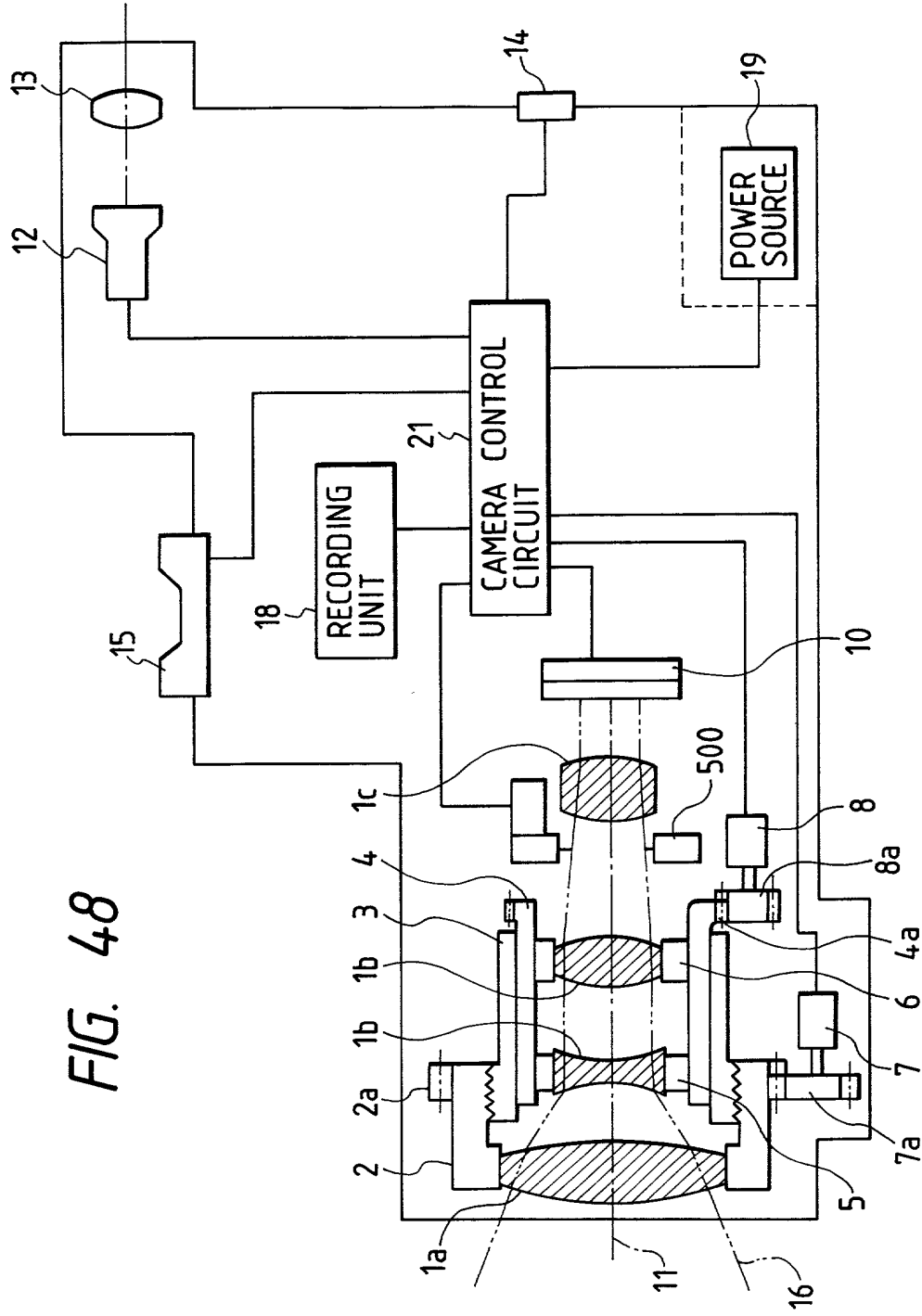
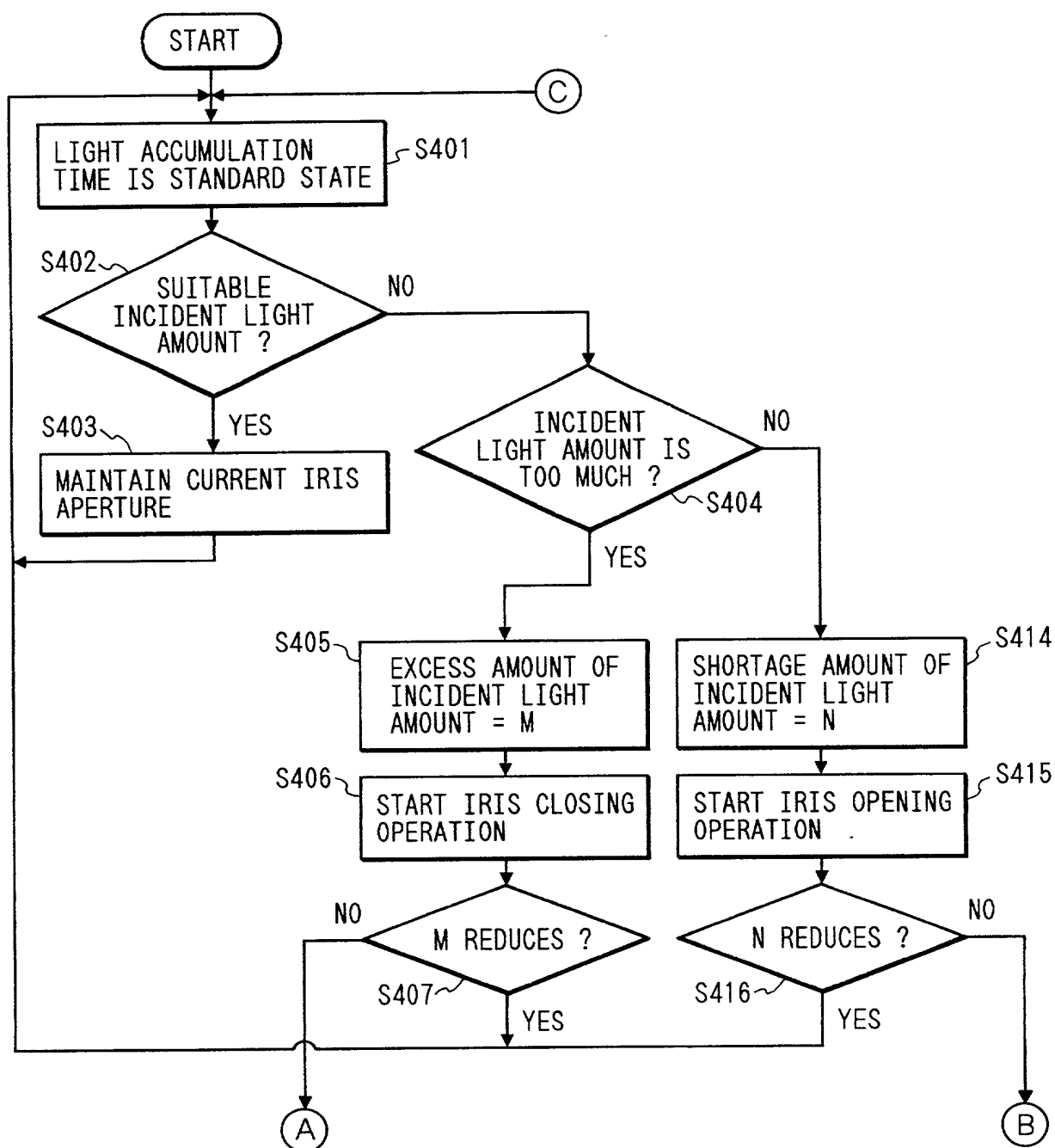




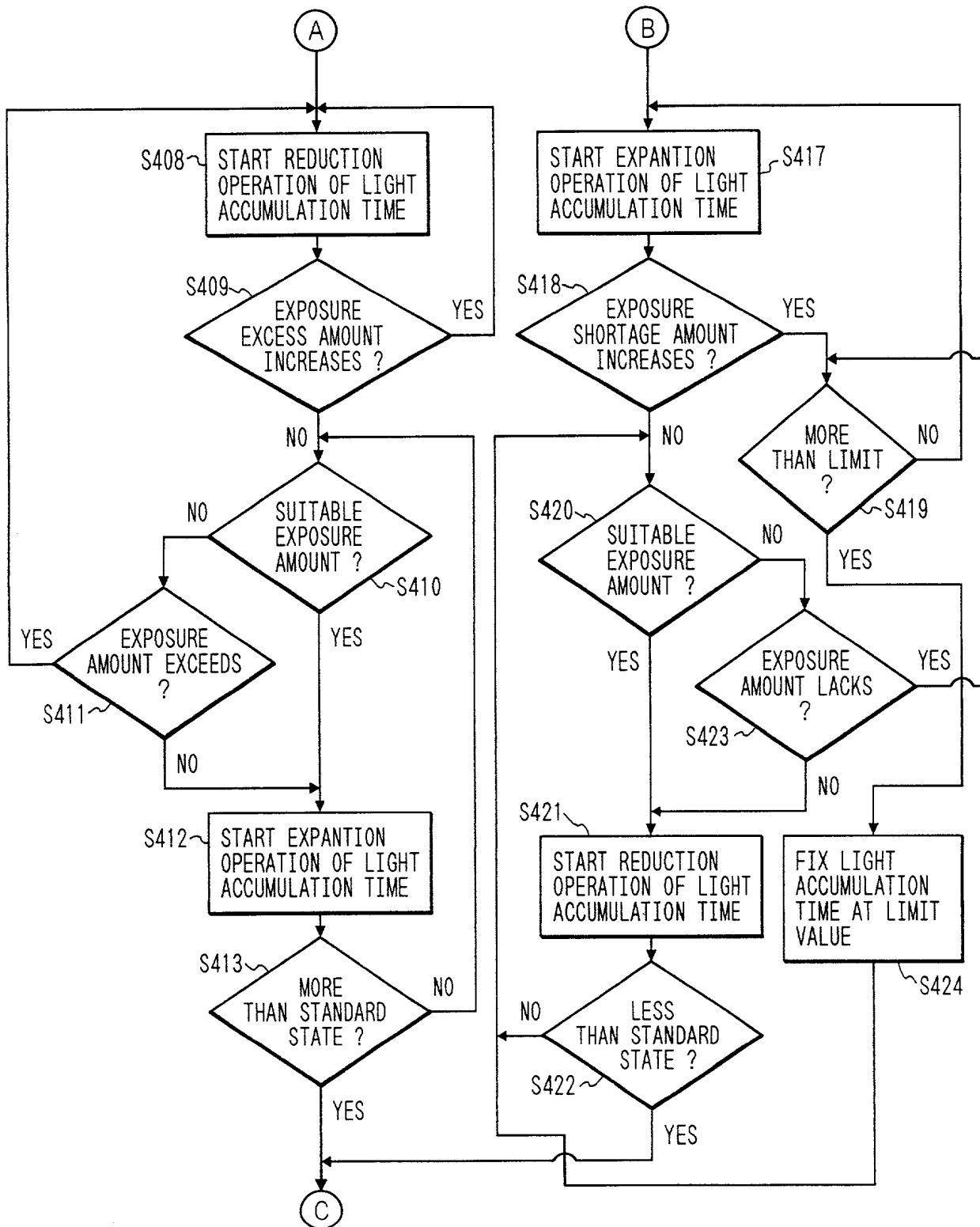
FIG. 49A



0.6.FIG.	SUBCLASS
CLASS	
APPROVED	DRAFTSMAN

DATE: 11/11/83 BY: [illegible]

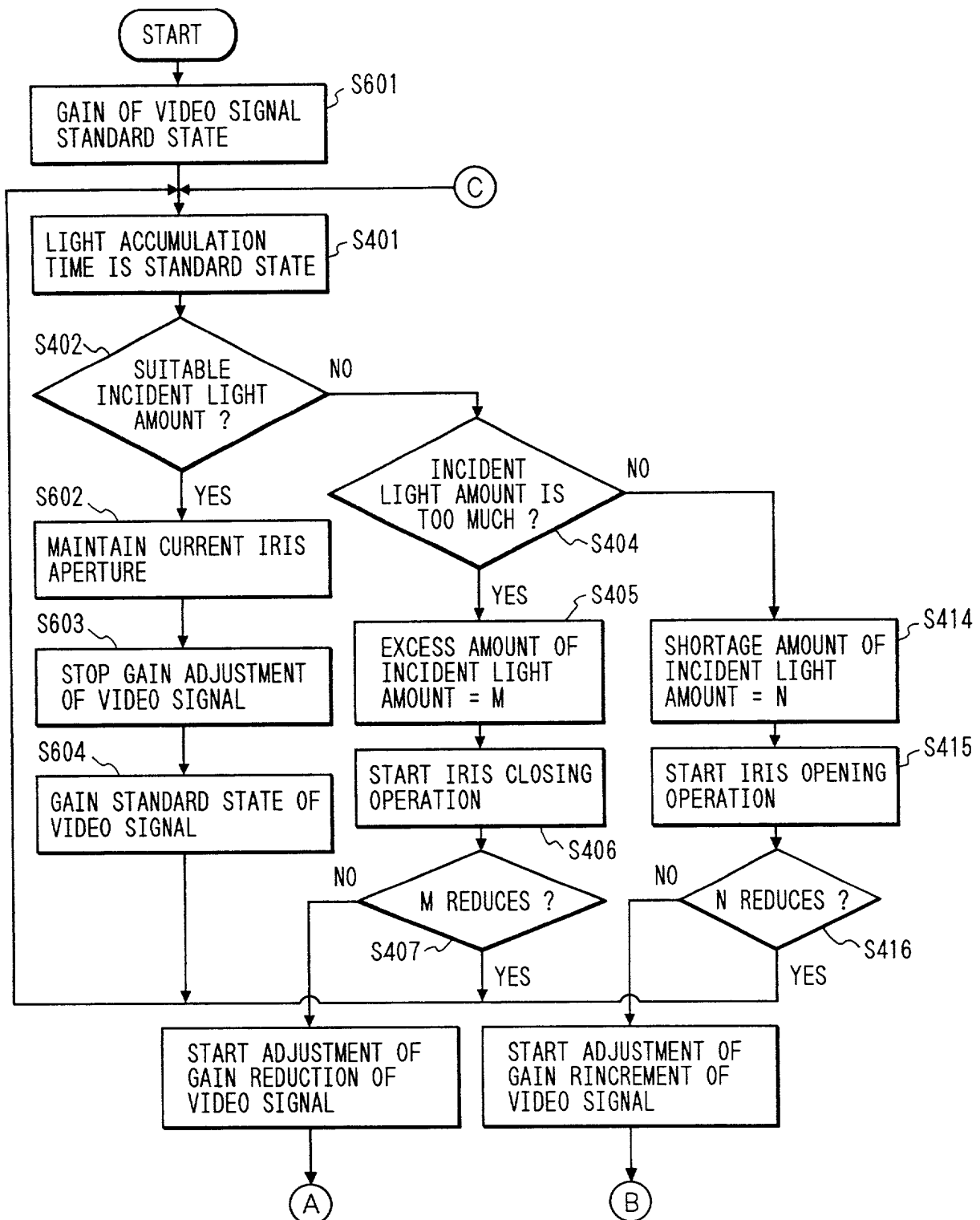
FIG. 49B



0.6 FIG.  
CLASS  
SURCLASS  
APPROVED BY  
DRAFTSMAN

SECRET

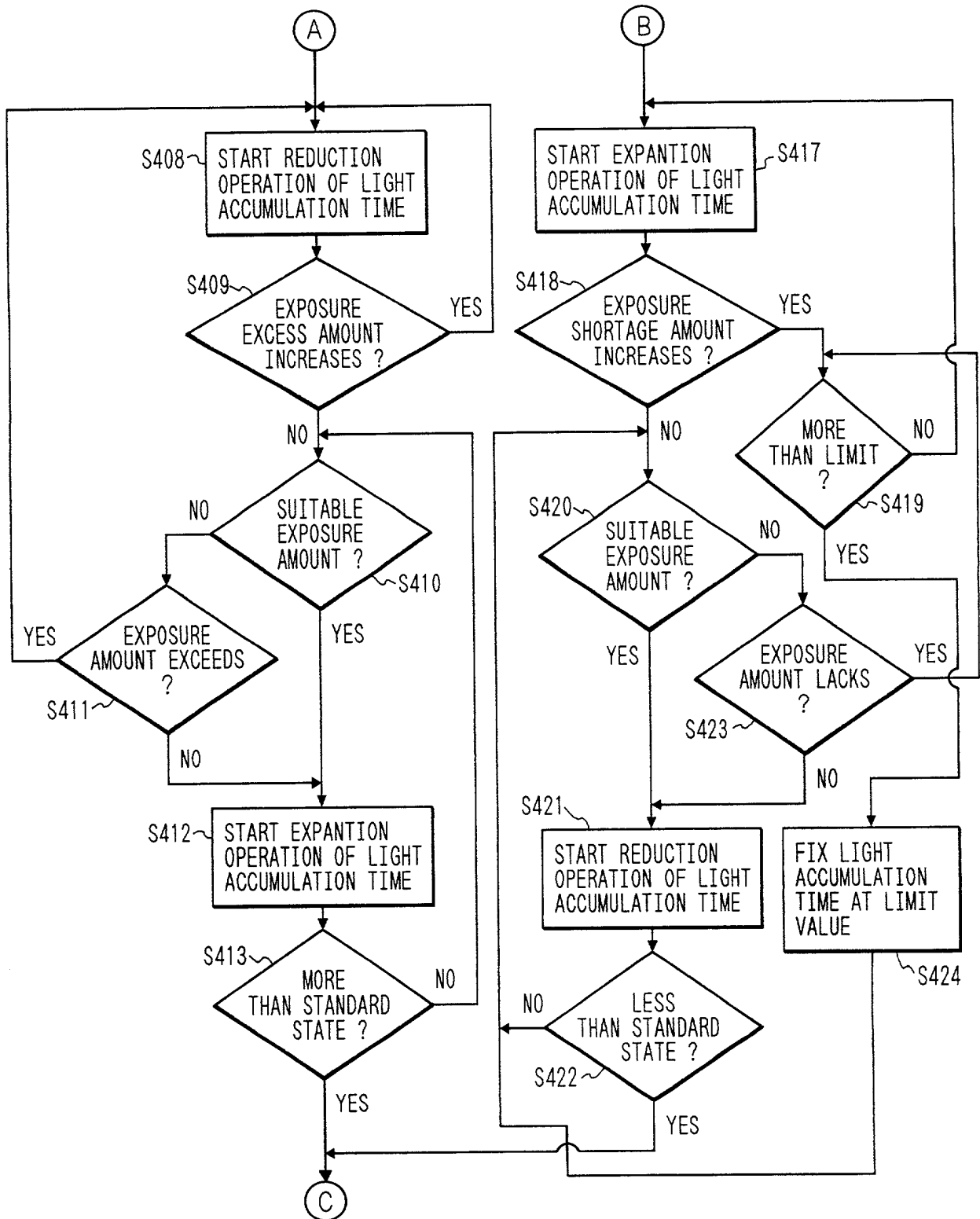
FIG. 50A



0. G. FIG.	SUBCLASS
APPROVED BY	DRAFTSMAN

"SECRET"

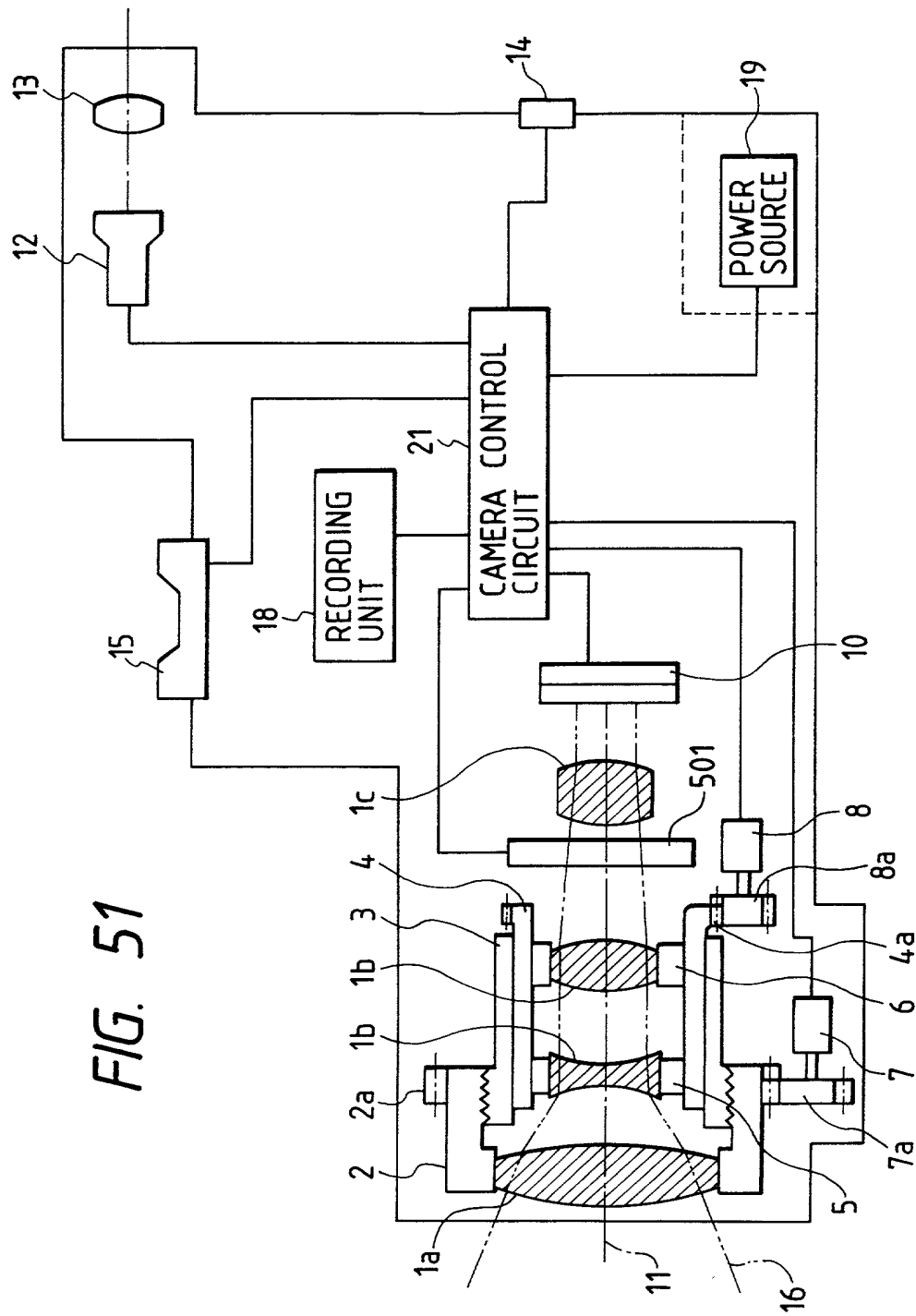
FIG. 50B



0.6 FIG.	SUBCLASS
APPROVED BY	DRAFTSMAN

Approved by

FIG. 51

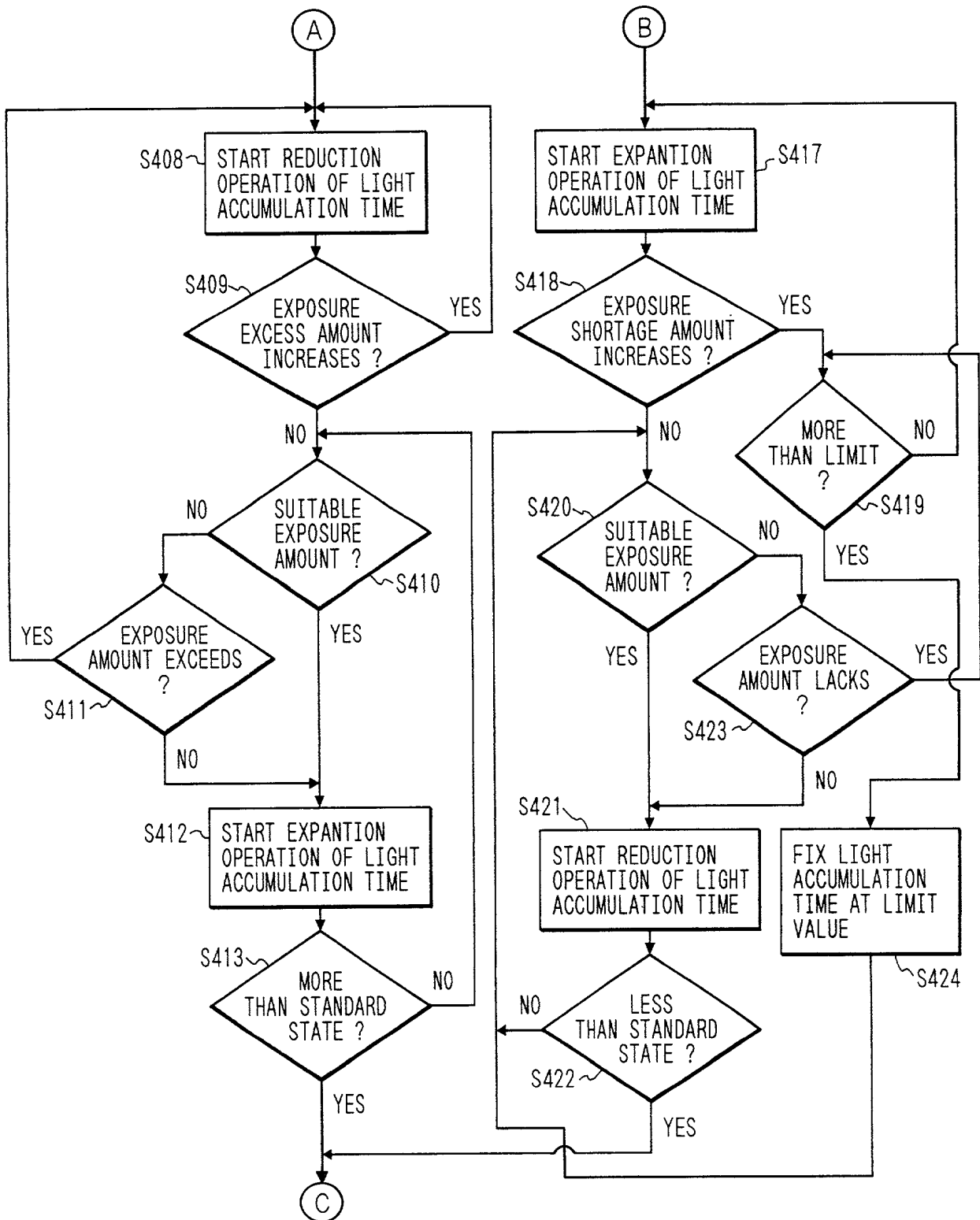


```

graph TD
    START([START]) --> S401[LIGHT ACCUMULATION TIME IS STANDARD STATE]
    S401 --> S402{S402  
SUITABLE INCIDENT LIGHT AMOUNT ?}
    S402 -- YES --> S801[MAINTAIN CURRENT MATERIAL ELEMENT'S TRANSMISSION FACTOR]
    S801 --> A((A))
    S402 -- NO --> S404{INCIDENT LIGHT AMOUNT IS TOO MUCH ?}
    S404 -- YES --> S405[EXCESS AMOUNT OF INCIDENT LIGHT AMOUNT = M]
    S405 --> S802[START REDUCTION OPERATION OF MATERIAL ELEMENT'S TRANSMISSION FACTOR]
    S802 --> S407{M REDUCES ?}
    S407 -- YES --> A
    S407 -- NO --> A
    S404 -- NO --> S414[SHORTAGE AMOUNT OF INCIDENT LIGHT AMOUNT = N]
    S414 --> S803[START INCREMENT OPERATION OF MATERIAL ELEMENT'S TRANSMISSION FACTOR]
    S803 --> S416{N REDUCES ?}
    S416 -- YES --> B((B))
    S416 -- NO --> B
    A --> C((C))
    C --> S401

```

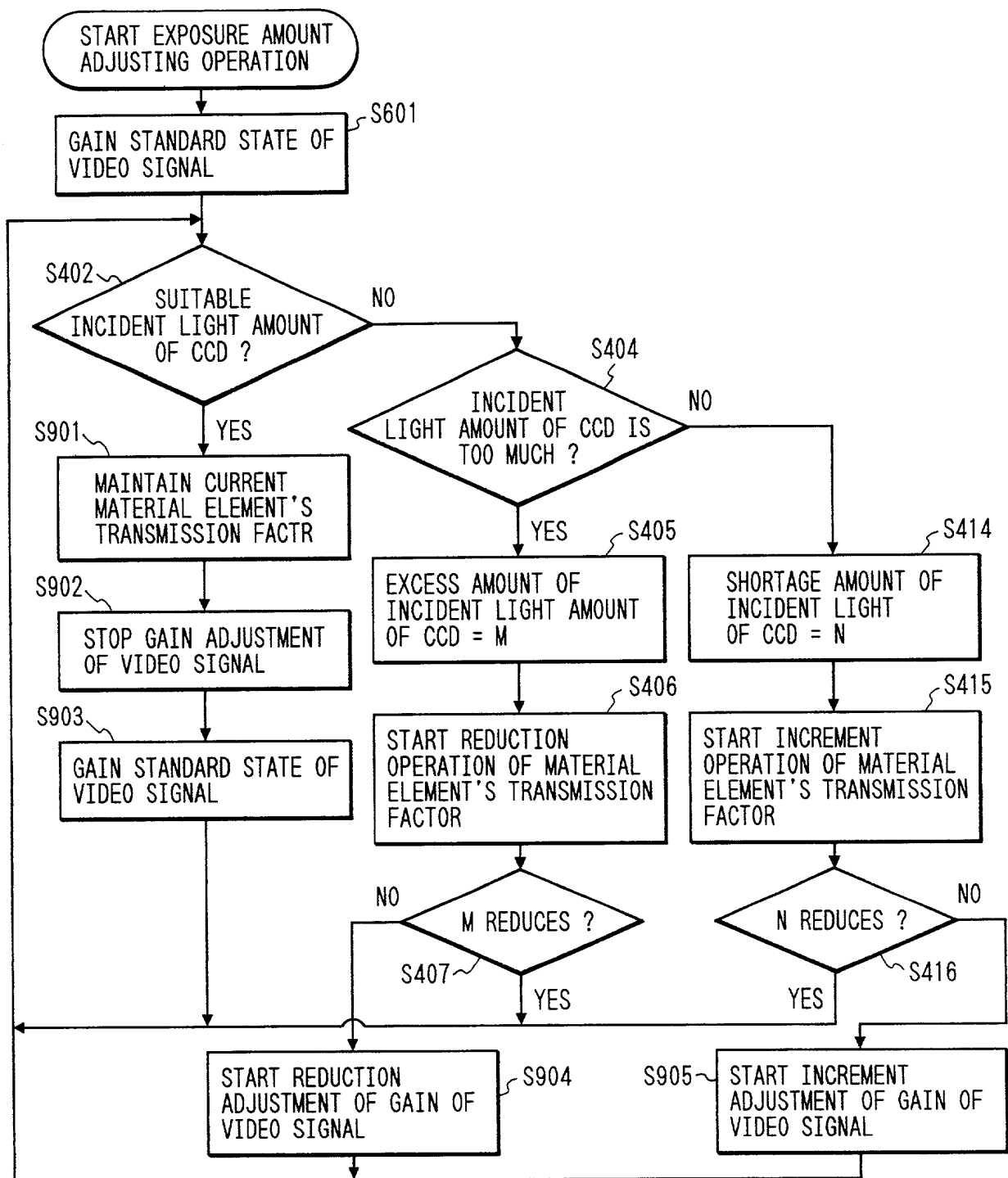
FIG. 52B



C.G. FIG.	SUBCLASS
APPROVED BY	DRAFTSMAN

Approved by

APPROVED  
BY CLASS SUBCLASS  
DRAFTSMAN





APPROVED	BY	CLASS	SURGLASS	O.G. FIG.
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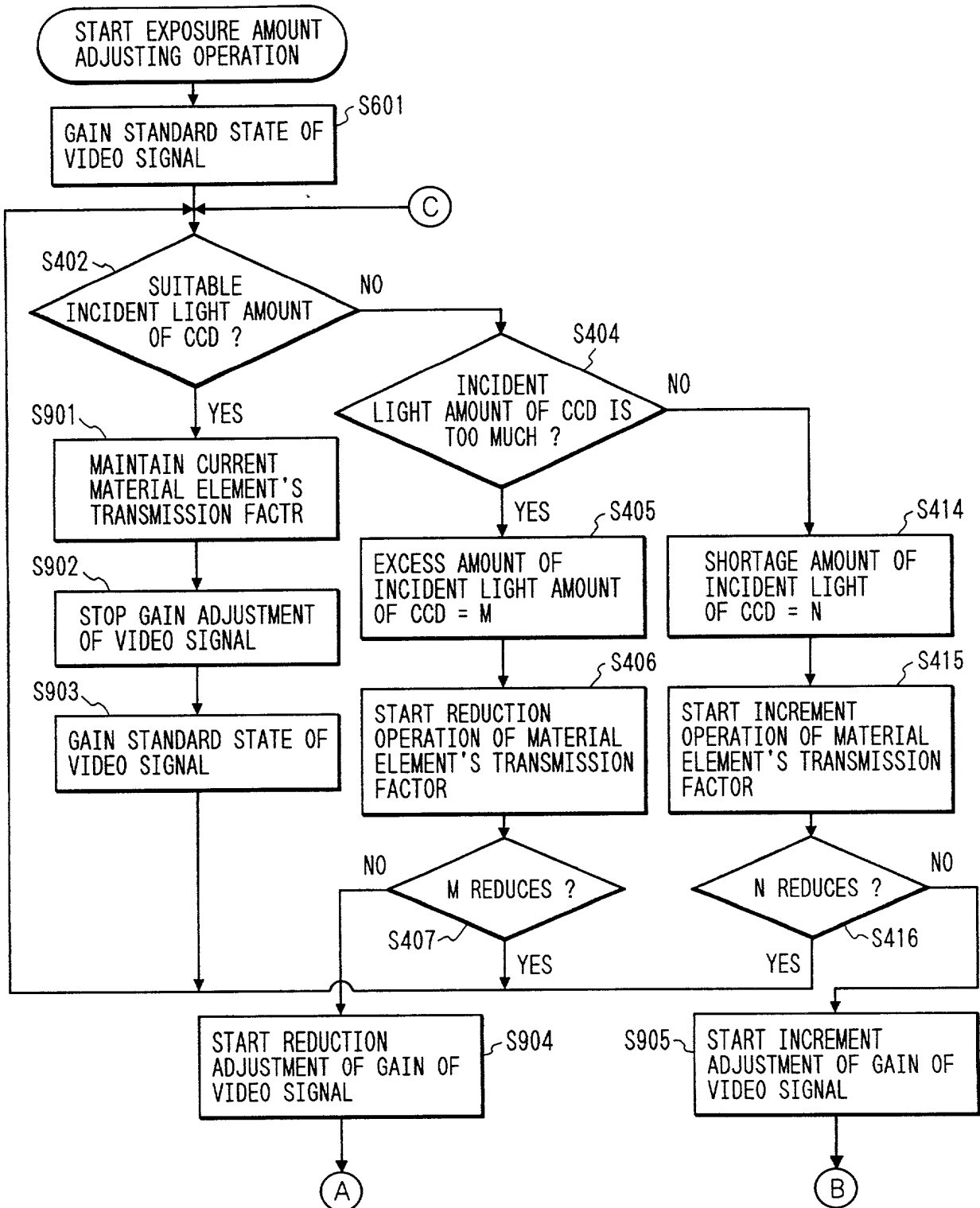
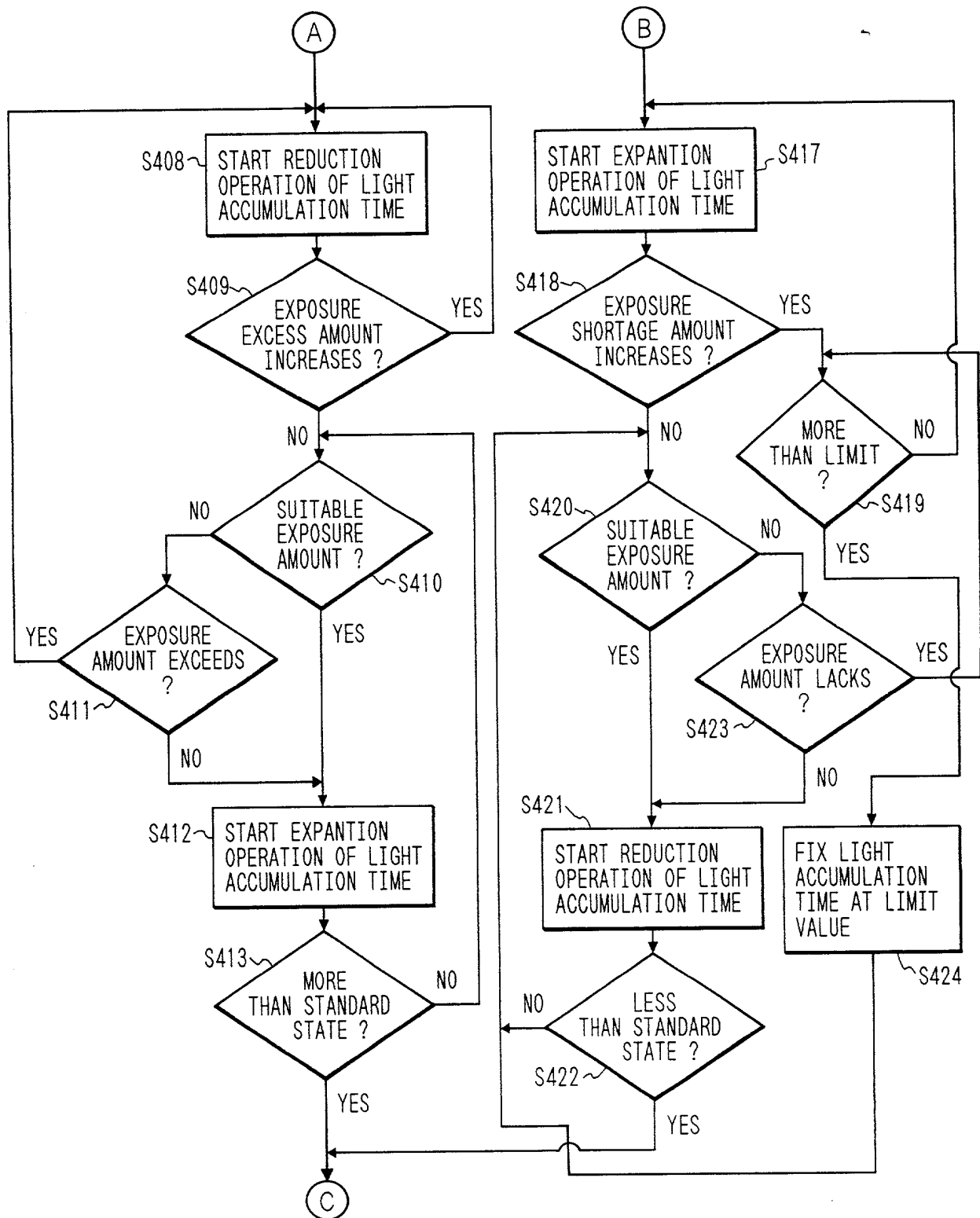


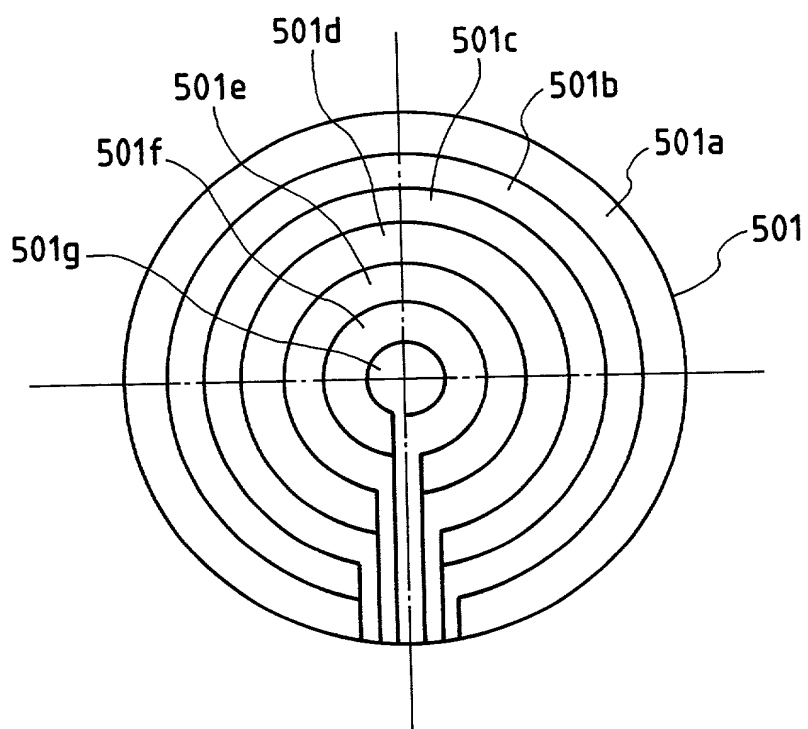
FIG. 54B



0.6 FIG. CLASS SURCLASS  
APPROVED BY DRAFTSMAN  
checked

APPROVED BY DRAFTSMAN	CLASS	SUBCLASS
	0.6 FIG.	

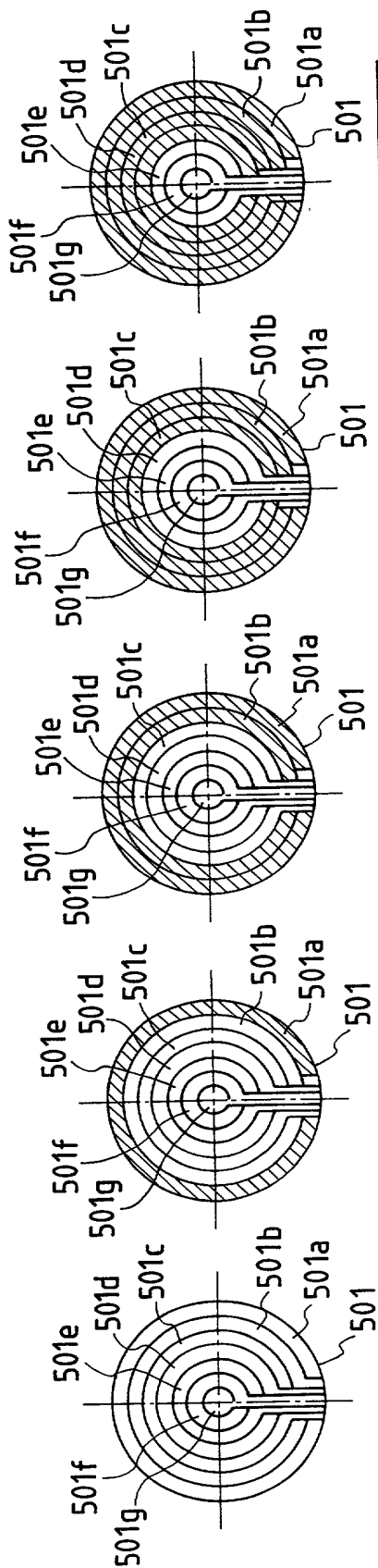
FIG. 55



Approved by: [Signature]

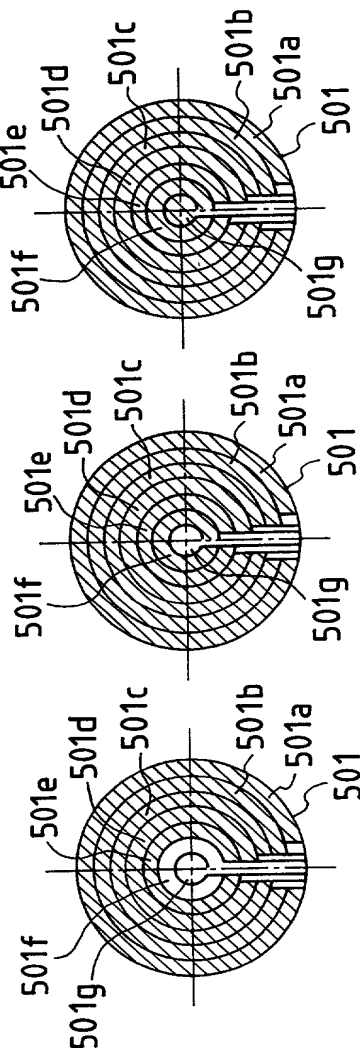
APPROVED		O.C. FIG.	
BY		CLASS	
DRAFTSMAN		SUBCLASS	

FIG. 56A FIG. 56B FIG. 56C FIG. 56D FIG. 56E



LARGE TRANSMISSION FACTOR (DEPTH OF FIELD IS SHALLOW)

FIG. 56F FIG. 56G FIG. 56H



SMALL TRANSMISSION FACTOR (DEPTH OF FIELD IS DEEP)

AREA DENOTES AREA HAVING SMALL TRANSMISSION FACTOR

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COMBINED DECLARATION AND POWER OF ATTORNEY  
FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:  
My residence, post office address and citizenship are as stated below next to my name;  
I believe I am the original, first and sole inventor (if only one name is listed below) or an original,  
first and joint inventor (if plural names are listed below) of the subject matter which is claimed and  
for which a patent is sought on the invention entitled VIDEO CAMERA

\_\_\_\_\_, the specification of which  
☒ is attached hereto. ☐ was filed on \_\_\_\_\_ as Application  
Serial No. \_\_\_\_\_  
and was amended \_\_\_\_\_ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification,  
including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application  
in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign  
application(s) for patent or inventor's certificate listed below and have also identified below any foreign  
application for patent or inventor's certificate having a filing date before that of the application on which  
priority is claimed:

Country	Application No.	Filed (Day/Mo./Yr.)	Priority Claimed (Yes/No)
JAPAN	4-216614	23 July 1992	Yes
JAPAN	4-222280	30 July 1992	Yes
JAPAN	4-224340	24 August 1992	Yes
JAPAN	4-247887	17 September 1992	Yes
JAPAN	4-326077	11 November 1992	Yes
JAPAN	Not yet assigned	30 June 1993	Yes

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49

COMBINED DECLARATION AND POWER OF ATTORNEY  
FOR PATENT APPLICATION

(Page 2)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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